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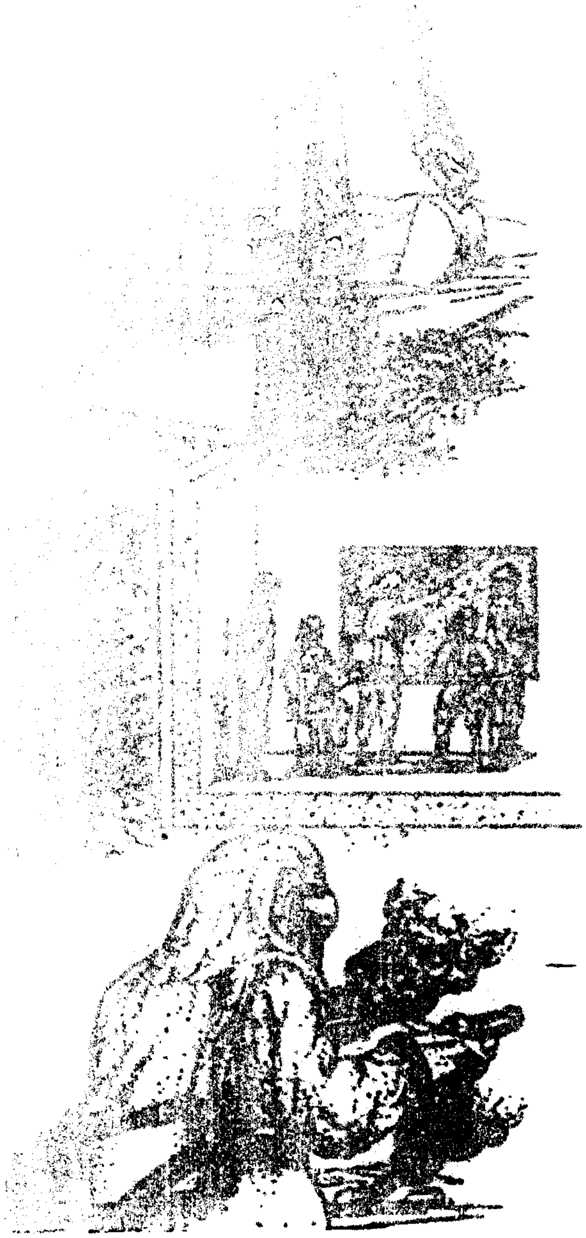

HANDHELD DELIVERY SYSTEM FOR MODIFIED BORON-TYPE FIRE EXTINGUISHMENT AGENT

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A handheld, portable extinguisher was developed for Boralon, a modified Boron-type Class D fire extinguishing agent. The development of this unit progressed through the design, prototype, and final product stages.

Two prototypes were designed as valved, stored-pressure types using Boralon compatible materials in critical areas exposed to the agent. The units were tested at an operating pressure of 200 lbf/in^2 and an agent capacity of 2 to 3 gallons to determine the optimum application rate, throw range and throw pattern. The most favorable unit was tested for reliability.

The information obtained in the prototype testing was developed further into a final design. This design specified a stored-pressure type that was sealed with a frangible plug or splined rupture disk and was activated by depressing the handle and removing the seal. Further requirements of a fill ratio of 75 percent agent to 25 percent pressure head at

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200 lbf/in^2 and an agent fill capacity of at least 2 gallons were also specified. Two manufactured units were found that met the criteria. An extinguisher with a frangible plug seal was successfully tested against 30- and 50-pound magnesium fires.

Both the frangible plug and splined rupture disk designs satisfy the final design requirements of the handheld Boralon extinguisher. Both types are recommended for use in the Draft Military Specification for this unit.

PREFACE

This report was prepared by the New Mexico Engineering Research Institute (NMERI), University of New Mexico, Albuquerque, New Mexico 87131, under contract F29601-84-C-0080 for the Engineering and Service Center, Tyndall Air Force Base, Florida 32403-6001, and the Naval Air Systems Command, HQ NAVAIR, Washington, DC 20361. Mr. Charles Risinger was the project officer for HQ AFCESA and Ms. Phyllis Campbell was the project officer for NAVAIR. This report summarized work done between 30 July 1987 and 31 May 1988.

This report has been reviewed by the Public Affairs Office (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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SECTION I
INTRODUCTION

A. OBJECTIVE

The objective of this effort was to develop and test a handheld portable delivery system for use with the modified boron-type fire extinguishing agent for metal fires.

B. BACKGROUND

A need exists for an extinguishing agent and accompanying delivery system that are effective against complex geometry metal fires. A modified boron type fire extinguishing agent (Boralon*) and a 40-gallon capacity delivery system have been developed to meet this need (References 1 and 2). This agent and its delivery system have proven effective against complex geometry metal fires containing up to 200 pounds of magnesium metal. Further research has now been conducted to develop a smaller, handheld delivery unit to control small or incipient metal fires.

Though Boralon is an effective extinguishing agent for metal fires, it requires special handling and isolation from moisture and certain elastomeric/polymeric materials commmonly used in extinguisher construction (Reference 1). The agent hydrolyzes and produces a precipitate when exposed to moisture from the atmosphere, condensation, or other water source. This precipitate interferes with agent delivery systems by clogging hoses, valves, and nozzles. Handheld 2.5-gallon extinguishers containing trimethyoxyboroxine (TMB), an important component of Boralon, have been developed for the United States Navy (Reference 3). These extinguishers were difficult to maintain and were unreliable. In earlier research

*A series of Boralon agents were actually developed; however, one agent, Boralon-1-30V proved particularly effective. In general, in this report the singular term "Boralon" refers to Boralon-1-30V.

selected polymers and elastomers were tested to determine their compatibility with Boralon agents (Reference 1). Teflon, polyvinyl chloride (PVC), and Delrin were found to be the most compatible with TMB, and neoprene, buna, and silicone elastomers were among the least compatible. All common metals, such as aluminum, brass, mild steel, stainless steel, and copper, are compatible with TMB (Reference 4). Therefore, a Boralon extinguisher can be constructed with a common extinguisher shell but must have either valve seats and seals of compatible materials or must be designed to isolate any noncompatible components from the agent by means of rupture disks or similar devices.

Tests with the 40-gallon unit proved that an externally pressurized rupture-disk system is feasible for large extinguishing systems (Reference 2). This unit, however, requires truck transportation. The restrictive size and weight limitations of a handheld unit might make it difficult to design a similar externally pressurized system for handheld extinguishers. Internally pressurized isolated* and valved systems were considered in the design of the handheld unit.

C. SCOPE/APPROACH

The handheld unit is required to be portable, sized for use on existing or future crash rescue vehicles, reliable, and maintainable. The unit must hold 2-5 gallons of agent and be pressurized externally or stored under pressure. If the unit is to be reused, only materials that have been proven compatible with Boralon (References 1 and 2) can be used in the construction of the system. The agent must be separated from ambient moisture by means of appropriate valves and/or rupture disks or similar isolation devices.

*The term "isolated system" is used in this report to denote a system with a rupture-disk, frangible plug, or a similar device. This type of system contrasts with a "valved" system.

Prototype designs for the handheld unit considered both the isolated and valved systems. Valved, stored-pressure-unit designs using Boralon-compatible materials were finalized for the prototype units. Two units -- a NMERI prototype and a Mine Safety Appliances Company (MSA) prototype -- were constructed and prepared for testing.

Prototype units were tested according to an approved test plan that addressed optimum application rates, throw range, throw pattern, nozzle design, and metal fire size. System reliability tests were also conducted to determine resistance to aging, in-service stress, and extremes of ambient conditions.

The testing of the prototype units consisted of four categories: (1) spray pattern testing, (2) medium- and (3) large-scale metal fire testing, and (4) system reliability testing. The spray pattern testing was conducted to preliminarily determine the nozzle design needed for each unit to optimize application rate, throw range, and throw pattern. The medium- and large- scale tests evaluated the units against actual magnesium fires. In the medium-scale tests, small amounts of magnesium were individually ignited and the operating pressures, agent amounts, and nozzle designs of each unit were further evaluated. The large-scale tests involved larger magnesium fires, during which the nozzle, operating pressure, and agent amount choices were finalized for both units. In the reliabilty tests, the fully charged NMERI prototype was subjected to aging, vibration, and temperature shock, and was then tested for leaks, flow, and discharge.

After the prototypes were favorably tested and the design parameters for the extinguisher were chosen, a final design was prepared. This design seals the agent in the cylinder at operating pressure until usage is required. A handle activates the unit by removing a seal when depressed.

A number of extinguisher companies were contacted. It was discovered that two companies, Metalcraft, Inc. and F.P.S. International, Inc., manufacture extinguishers which store the agent under pressure and seal the unit from the atmosphere with a splined rupture disk or a frangible plug. The units are activated when the handle/nozzle assembly is screwed on and the handle is depressed. Both of these extinguishers are types which would satisfy the final design requirements.

F.P.S. International, Inc., prepared a frangible plug extinguisher which was tested against actual magnesium fires. However, both extinguisher types (splined rupture disk and frangible plug) would fulfill the design requirements of the Boralon extinguisher; both types are recommended for use.

SECTION II

TECHNICAL APPROACH AND SYSTEM DESIGN

A. CHARACTERISTICS OF BORALON

Boralon extinguishing agents were developed as highly effective liquid agents for combating metal fires. Other agents tested (which included liquids, powders, gels, and slurries) were less effective and, in some cases, were violently reactive with the fire (Reference 1). Boralons were also tested in combined hydrocarbon fuel-metal fires and were proven to be compatible with Aqueous Film-Forming Foam (AFFF) and nonreactive with burning hydrocarbons. These combined fuel fires were successfully extinguished using developed coapplication techniques in which Boralon and AFFF were applied together from different sources (Reference 2).

Boralons are combinations of two firefighting agents, TMB and Halon. Research shows that a combination of 70 percent TMB and 30 percent Halon 1211 (both by volume) provides the best characteristics (References 1 and 2). This mixture, Boralon-1-30V, referred to simply as Boralon in the remainder of this report, combines the best qualities of each of these agents and minimizes those that are less desirable. Boralon, however, does have some limitations that need to be addressed.

The main component of Boralon, TMB, readily reacts with moisture from the atmosphere and other sources to produce a precipitate. The addition of Halon 1211 to the TMB reduces this reaction; however, during storage the agent must still be isolated from any moisture source. The white precipitate is oily and gummy to the touch and can block valves, hoses, nozzles, or other openings in an extinguishing system. Exposure to even small amounts of moisture can cause this reaction and produce an extinguisher system malfuction (Reference 1).

TMB/Halon mixtures also react with certain elastomers and polymers commonly used in extinguisher construction. Tests show that many materials commonly used in O-rings and valve seals react with Boralon agents and deteriorate rapidly (Reference 1). These materials -- among them buna, neoprene, and silicone elastomers -- are not recommended for use in Boralon extinguishing systems. Other materials, such as Teflon, PVC, and Delrin, are more resistant to TMB and can be used in extinguishing systems utilizing Boralon. Separate tests involving the exposure of common metals to TMB show that metals commonly used in extinguisher construction -- mild steel, stainless steel, copper, and aluminum -- are nonreactive with this agent (Reference 4).

Boralon is affected by operating temperature restrictions that govern the viscosity of the agent and can affect its performance in the field. Although the agent can be frozen without any adverse performance effects, it is recommended that it be kept at temperatures between -22 $^{\circ}$F and 140 $^{\circ}$F to keep the density/viscosity at a level that allows the agent to freely flow when expelled (Reference 2).

These characteristics and restrictions limit the systems which can be utilized to two different types. A system must either isolate the noncompatible extinguisher components from the Boralon agent until the unit is used or it must be constructed of materials compatible with the agent. Sealed systems that are internally pressurized and activated when the seal is removed would effectively isolate the agent from the ambient environment and any noncompatible materials. Two types of sealing devices, a splined rupture disk and a frangible plug, could be used to satisfy this requirement. It was more timely and economical for test purposes, however, to produce a prototype which used a ball valve, valve seats, O-rings, and hoses manufactured of materials compatible with the agent.

B. CHARACTERISTICS OF MAGNESIUM FIRE

The study of metal combustion has been documented in several reports, and the mechanisms and limiting factors which control the combustion have been studied and evaluated. The following is a synopsis of the findings of these reports that pertain to magnesium metal.

Metals can be separated into two combustion groups -- volatile and nonvolatile metals. Magnesium, a volatile metal, has combustion characteristics which are different from aluminum or steel (nonvolatile metals). The combustion of magnesium takes place in the vapor phase, or the portion of the fire that is above the surface of the metal. This type of combustion is characterized by a high rate of burning, a blueish-white intense (luminous) flame, and the formation of a dense oxide smoke.

This vapor-phase burning is dependant on pressure and the availability of oxygen, to related limiting factors. Research and testing have shown that the moisture content of surrounding air does not affect the combustion process appreciably (References 5-9).

This dependency on pressure and oxygen can effect the burning rate or intensity of a magnesium fire. The vapor-phase burning is increased as the atmospheric or surrounding pressure is increased. This increase in pressure also increased the partial pressure of the atmospheric gases, allowing more oxygen to be present. This increase in oxygen can intensify the fire.

The atmospheric pressure and related partial pressure of oxygen decreases with increase in altitude from sea level. Testing has shown that magnesium burned 12 to 18 percent longer at higher altitudes when fires supplied with oxygen levels similar to sea level and 5280 feet were tested (Reference 5). The burning rate was inversely related to the intensity of the fire -- the longer the burning rate, the less intense the fire. Minute amounts of various inert gases were added to the flames of these fires to stabilize them.

The recent testing of firefighting chemicals, such as Boralon, against magnesium fires has validated this effect on combustion. Fires which contained the same amounts of magensium required more agent at sea level to extinguish the fires than at an altitude of 5280 feet. The same firefighting techniques were used for each test. This difference in testing results should not, however, effect the original agent comparison work. This work was all conducted at the same altitude.

C. SYSTEM REQUIREMENTS

A handheld fire extinguishing unit must be easily portable, simple to use and maintain, and reliable. Standard handheld extinguishers vary in dimensions and weights; however, the average 2.5-gallon-capacity unit is 24 inches in height, 8 to 9 inches in diameter, and weighs 40 to 45 pounds when charged. Such extinguishers are stored-pressure units that release their contents when a plunger valve, actuated by pressing down on the extinguisher handle, is opened. They are intended for single-event usage only and require that the unit be recharged after each use. They are stored in readily accessible areas until needed and are checked for leakage and damage on a regular, sometimes yearly, basis.

The Boralon handheld extinguishing unit should meet similar specifications. The unit also must isolate the agent from ambient moisture with appropriate rupture disks, frangible plugs, or valves. All extinguisher parts coming into contact with the agent must be constructed of agent-compatible materials.

The unit must be capable of effectively extinguishing small magnesium and other metal fires. The nozzle, operating pressure, and agent amount should support this requirement.

D. PROTOTYPE DESIGNS

1. Introduction

Three types of system designs were initially considered. Two of these designs incorporated a rupture disk with internal or external pressurization. Since the rupture disk with external pressurization was successful for a larger Boralon unit (Reference 2), this concept was researched first. In this method, the sealed unit is actuated when a sudden burst of pressure ruptures the disk and pressurizes the unit from an externally attached source (such as a carbon dioxide cartridge). External pressurization increases the weight and cost of the unit and would be expensive to maintain.

The second system considered was a stored-pressure unit sealed by a rupture disk. A feasibility and cost analysis was conducted and several manufacturers were contacted. The disk would be ruptured by a plunger (or cutter) which would be attached to the underside of a handle on top of the extinguisher and actuated when the handle was pushed downward. The agent would then flow through the perforated opening and be expelled through the extinguisher hose. An extinguisher which incorporates the same stored pressure concept and uses a frangible plug instead of a rupture disk could also be considered.

Another commonly used method of actuating rupture disks in stored-pressure units employs an externally controlled, electrically detonated charge that bursts the disk. Costs for this system would include $250 for the rupture disk and union disk holder and $1500 to $2000 for the detonator unit. The disk and detonator would have to be replaced with every usage of the unit. These costs do not include the costs of the extinguisher shell, hose, nozzles, or the agent. This type of actuation system was designed for use in emergency deluge valves where an ultrafast opening valve is needed to prevent explosions from pressure buildup in pipes due to fire. They are not intended for use in high usage equipment. The high cost and maintenance of this type of unit prevent this concept from being viable.

The third concept of using conventional containment and actuating valves with Boralon-compatible materials was pursued for the prototype design. The NMERI prototype was constructed with a brass ball valve containing Teflon valve seats, without O-rings, to contain the Boralon in the extinguisher under pressure until usage. These valves ordinarily cost between $65 and $80 and can be used multiple times.

NMERI designed and constructed one system prototype (Appendix B). A second prototype was obtained from MSA and a standard ANSUL Halon 1211 extinguisher was obtained as a third extinguisher type.

2. NMERI Design

After research indicated that the sealed system would be too costly and difficult to design, construct, use, and maintain in the prototype stage, a design that used Boralon-compatible materials was pursued. This design included a brass containment ball valve with Teflon valve seats and a stainless steel extinguisher shell. The valve was fitted with a trip-proof locking safety handle designed to be operated in either a locked-closed or open position. A stored-pressure unit was designed according to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, to have an agent capacity of between 2 and 3 gallons and a working pressure of 100 to 200 lbf/in^2. A chemical-resistant hose, spray nozzle tip holder/actuator, and an assortment of nozzle tips were obtained. The nozzle tips had orifice diameters of 0.078 to 0.125 inches and delivered fluid in spray patterns ranging from a straight stream to a 15-degree cone. The nozzle tips were designed to produce unrestricted flowrates of between 0.91 and 11.12 gal/min of Boralon at 200 lbf/in^2.

3. Mine Safety Appliances Design

The MSA design converted an existing pressure tank and containment system into a Boralon-compatible system. This unit consisted of an adjustable brass cylinder shutoff containment valve, with nylon valve seats, and a mild steel shell. The unit was a stored-pressure type having an agent capacity of 2 gallons and a working pressure of 100 lbf/in^2. A Boralon-resistant, high-pressure hose, a nozzle holder and sprayer, and an assortment of nozzles were provided with the unit. The nozzles were designed to deliver the agent to the fire in a concentrated, straight stream. These nozzles had orifice diameters of 0.078 to 0.141 inches and were designed to deliver flowrates of 1.33 to 3.90 gal/min of Boralon agent at 100 lbf/in^2.

E. FINAL DESIGNS

1. Introduction

The final recommended design for the Boralon extinguisher was based on the information obtained from the prototype testing. The prototype demonstrated that a handheld portable extinguisher could be developed that would effectively control and suppress small magnesium fires if certain design and operating criteria were followed. The final design builds on this information and provides the user with a highly reliable product that requires minimal maintenance.

The first requirement of the final design was goverened by the characteristics of the agent itself. Since Boralon will form a white, gummy percipitate when exposed to atmospheric moisture, the agent must be sealed in the extinguisher cylinder until ready for use. While conventional sealing devices, such as the prototype's ball valve, can be used, they are not foolproof. A high-integrity seal, such as a rupture disk or a frangible plug, must be used.

The next requirements relate to the readiness and functionability of the extinguisher. If the unit is sealed, it must be stored/sealed at its operating pressure. It must be able to contain this pressure without rupturing when the cylinder is subjected to various temperatures and rough handling.

The unit should have a simple actuating device to open the seal when the handle of the extinguisher is depressed and reseal the extinguisher when released. This would give the intermittent flow capability needed to combat a magnesium fire.

The extinguisher should be relatively lightweight. Most handheld portable 2.5-gallon Halon extinguishers weigh between 40 and 45 pounds. While heavier extinguishers are allowed, the Boralon unit should not exceed this weight if it is designed to be portable. This unit weight would require the extinguisher to contain between 2 to 2.5 gallons of Boralon. The prototype testing showed that to be sufficient to extinguish small magnesium fires.

Of several extinguisher manufacturers contacted, two (Metalcraft, Inc. and F.P.S. International, Inc.,) could supply such an extinguisher. The Metalcraft, Inc. extinguisher uses a splined rupture disk which, when sealed, allows the cylinder to be a separate unit from the handle/nozzle assembly. The handle/nozzle assembly is screwed on to the cylinder in the field when usage is required. The handle/nozzle assembly activates the unit when the handle is pressed downward. This action forces a plunger into the disk and ruptures the seal. The assembly is designed to allow intermittent flow by depressing and releasing the handle. When the handle is released, a secondary seal temporarily reseals the unit. The F.P.S. International, Inc., unit operates under the same principle; however, a frangible plug is used as a seal. The plug shears off when the handle is depressed, opening the seal. This unit has the same intermittent flow capability.

Both of these types of extinguishers fulfill the extinguisher requirements. Therefore, to provide the user a choice, both design types are recommended.

2. Comparison of Specifications

The following discussion compares the regulations and standards that could be used to define the design and construction of the handheld Boralon extinguisher in the draft military specification. Several standards and regulations can be referenced by extinguisher manufacturers in the design and production of different extinguisher products. This discussion compares the requirements of these documents and formulates decisions as to which of them are required in the military specification. An extensive comparison of these regulations is given in Table 1.

The Boralon extinguisher could be classified as either a refillable/reuseable or disposable unit (References 10 and 11). The agent is soluble in water and can be flushed out of the cylinder and handle/nozzle assembly after the extinguisher is used. However, this must be done very quickly or the white precepitate will coat the inside of the tank and handle/nozzle assembly. After the precipitate dries, it is difficult to remove from surfaces.

If the unit were classified as refillable/reuseable, the cylinder, handle/nozzle assembly, and hose would have to be flushed with water within a few hours of usage and be allowed to dry. The handle/nozzle assembly could then be retained and only the cylinder would have to be sent back to the manufacturer for refilling.

If the unit were classified as disposable, the handle/nozzle assembly could be flushed and dried, the cylinder safely disposed, and another cylinder installed. The handle/nozzle assembly would need to be inspected on a regular basis to ensure its integrity.

The cylinder could be constructed of aluminum or steel and would be required to be hydrostatically tested to either 2 or 3 times its operating pressure (References 10-14). If an extinguisher were classified as a disposable unit, an aluminum cylinder tested to double its operating pressure is sufficient (Reference 11). However, a more durable product would be produced if the cylinder were steel and tested to triple its operating pressure (Reference 13). Because equipment may receive rough handling, the cylinder should be manufactured to the tougher regulation. Manufacturers are allowed to produce extinguisher cylinders that comply with any of these regulations or standards. All that is required is that the cylinder be clearly stamped with its DOT rating.

A safety pressure relief device need not be specified for the extinguisher. Certain DOT regulations (Reference 12 and 13) do not require an extinguisher to have a pressure relief unless its operating pressure exceeds 300 lbf/in^2 at 70 ^oF. The Boralon extinguisher operating pressure will be 200 lbf/in^2 -- well below the regulation minimum.

A pressure gauge is recommended by certain UL standards (Reference 10); however, none is required by Federal Regularions (References 11-13). The pressure gauge is used to give the operator a visual assurance that the extinguisher is ready for duty. This gives the operator an added measure of safety and also provides a quick inspection method that ensures the integrity of the seals. A pressure gauge is required for the Boralon extinguisher. A silicone oil-filled gauge could be used to prevent the agent from clogging the gauge.

The extinguisher should also be lightweight to ensure firefighting maneuverability. Although most standards will allow a portable extinguisher to weigh up to 60 pounds (Reference 10), a unit of this size and weight would be cumbersome to operate. The extinguisher should, therefore, weigh 40-45 pounds. This would allow the extinguisher to contain between 2 and 2.5 gallons of Boralon.

Certain standards also recommend that a handheld extinguisher be equipped with an intermittent discharge capability, allowing the unit to shut off when the handle is released (Reference 10). This capability is essential when fighting magnesium fires and is required of the extinguisher.

It is not necessary to obtain the approval of UL for this extinguisher. Only the Federal DOT standards are required by law. To obtain a UL listing would involve a long and expensive study by UL. However, several environmental, physical, and reliability tests contained in the UL specifications (Reference 10) should be used to evaluate the extinguisher. These tests are referenced in Section III of this report.

3. Conclusions

Both the splined rupture disk and frangible plug designs provide an extinguisher that meets all the requirements of a Boralon extinguisher. The unit will be a sealed, stored-pressure type that is activated by pressing the handle downward when ready for use.

Only certain DOT (Federal) regulations should be applied to the extinguisher. Standards written by voluntary control agencies, such as UL and NFPA, can be referenced; however, these are voluntary standards, not laws. The standards are specialized and are written for extinguishers that differ from the Boralon extinguisher. The Boralon extinguisher would be a "new, innovative product" and would require extensive testing by these agencies for appropriate standards to be written.

The extinguisher could be classified as either a refillable/reuseable or disposable unit. In each case, the cylinder would be returned/disposed and the handle/nozzle actuator assembly would be flushed thoroughly with water after each use and reused.

TABLE 1. COMPARISON OF REGULATIONS.

		49 CFR 178.50 (DOT)	49 CFR 178.65 (DOT)	49 CFR 173.306(C) (DOT)	UL 1093	NFPA 10
1.	Cylinder classification	Spec. 4B	Spec. 39	DOT-approved	Same as DOT	Same as DOT
2.	Cylinder rating, multiple of operating pressure	2	2	3	3[a]	2[a]
3.	Pressure relief required (at 200 lbf/in^2)	no	yes	no	no	no
4.	Pressure gauge	no	no	no	yes[b]	yes
5.	Weight limitations	none	none	none	60 lb	none
6.	Cylinder size limitations	27,803 in^3	1526 in^3	1100 in^3	none	none[c]
7.	Operating pressure limitations	500 lbf/in^2	500 lbf/in^2	240 lbf/in^2	none[d]	none[d]

[a]Unless other DOT rating is used.

[b]No, if unit is disposable.

[c]Based on tests and manufacturers recommendations.

[d]See DOT limitations.

The cylinder should be rated and hydrostatically tested to three times its operating pressure. This will allow it to meet the requirements of the standard DOT regulation for fire extinguishers (Reference 13). The cylinder should be constructed of mild steel unless an aluminum cylinder that meets the required rating can be manufactured.

No safety pressure relief device will be required. The extinguisher is considered a low-pressure cylinder by DOT (Reference 5). This will also help to prevent the Boralon from contacting atmospheric moisture. A pressure relief valve is designed to isolate the contents of a cylinder from the atmosphere until a certain pressure is reached. However, the seals of any valve can eventually deteriorate and leak, allowing the agent to escape.

A pressure gauge will be used with this extinguisher even though Federal regulations do not require it. The gauge can provide an added measure of safety and assurance that the unit is charged. The gauge could be silicone oil-filled to prevent the Boralon from clogging the gauge. The unit should be leak-tested, using appropriate techniques, and visually inspected at least every 3 months to test the integrity of the seals and check for agent leakage. The extinguisher should also be weighed every 6 months to determine if the gauge is faulty and if long-term leakage has occurred. Leaking units should be replaced.

SECTION III
PROTOTYPE TESTING

A. APPLICATION TESTS

1. Test Plan

A test plan was prepared and submitted for approval before testing of the prototype units was initiated. This document outlines all planned testing, explaines why each type of test was necessary for the evaluation of the units, and provides a safety plan to be implemented in emergency situations.

The proposed testing of the prototype units was divided into three categories: spray pattern testing and medium- and large-scale metal fire testing. The spray pattern testing was to be conducted to preliminarily determine the optimum application rate, throw range, throw pattern, and nozzle design for each unit. Final operating pressures, agent amounts, and the best nozzle designs were to be determined from the fire testing. A substitute agent, aqueous methylcellulose solution (Reference 2) having delivery properties similar to those of Boralon, was to be used for these tests. The medium- and large-scale tests were to be conducted to test the units against actual magnesium fires. In the medium-scale tests, 4-to 5-pound blocks of magnesium were to be individually ignited and the operating pressures, agent amounts, and nozzle designs of each unit were to be evaluated. The large-scale tests were to involve fires of up to 50 pounds of magnesium. The final nozzle, operating pressure, and agent amount choices were to be determined for both units.

This document was approved and permission was given to proceed with the testing. The MSA and NMERI units were then constructed and prepared for testing.

2. Spray Pattern Tests

These tests were conducted at the Civil Engineering Research Facility test area located at Kirtland Air Force Base, Albuquerque, New Mexico, between 23 and 24 November 1987. A methylcelluose solution (Reference 2) was used for this testing to minimize costs. In accordance with the test plan, a test layout bed was set up with witness cups placed every 2.5 feet from 20 to 32.5 feet, to capture the maximum amount of agent expelled from the units tested (Figure 1).

The NMERI prototype unit was tested at pressures ranging from 100 to 200 lbf/in^2 and agent amounts varying from 2 to 2.5 gallons. Various nozzles, designed to produce flow rates of between 0.91 and 11.12 gal/min of Boralon at 200 lbf/in^2, were used in the testing. These nozzles produced spray patterns ranging from a straight stream to a 15-degree cone in area coverage.

Two nozzles, Spraying Systems Model Numbers 1560 (15-degree spray pattern, 0.188-inch orifice opening) and 0020 (straight-stream spray pattern, 0.125-inch orifice opening), provided the best throw patterns, discharge rates, and throw ranges. A working pressure of 200 lbf/in^2 permitted flow rates of 2.67 to 4.75 gal/min and throw ranges of 27.5 to 45.0 feet. The original amount of agent used in each test affected the throw range of the unit. When the amount of agent was decreased from 2.5 to 2.0 gallons, the throw range was increased. This effect on throw range was tested further in the medium- and large-scale magnesium fire tests.

The MSA unit was tested at its working pressure of 100 lbf/in^2 and recommended agent capacity of 2 gallons. Flow rates of 1.1 to 1.6 gal/min and throw ranges of 30 to 45 feet were attained.

Both units were shipped to Tyndall Air Force Base for the medium- and large-scale magnesium fire tests.

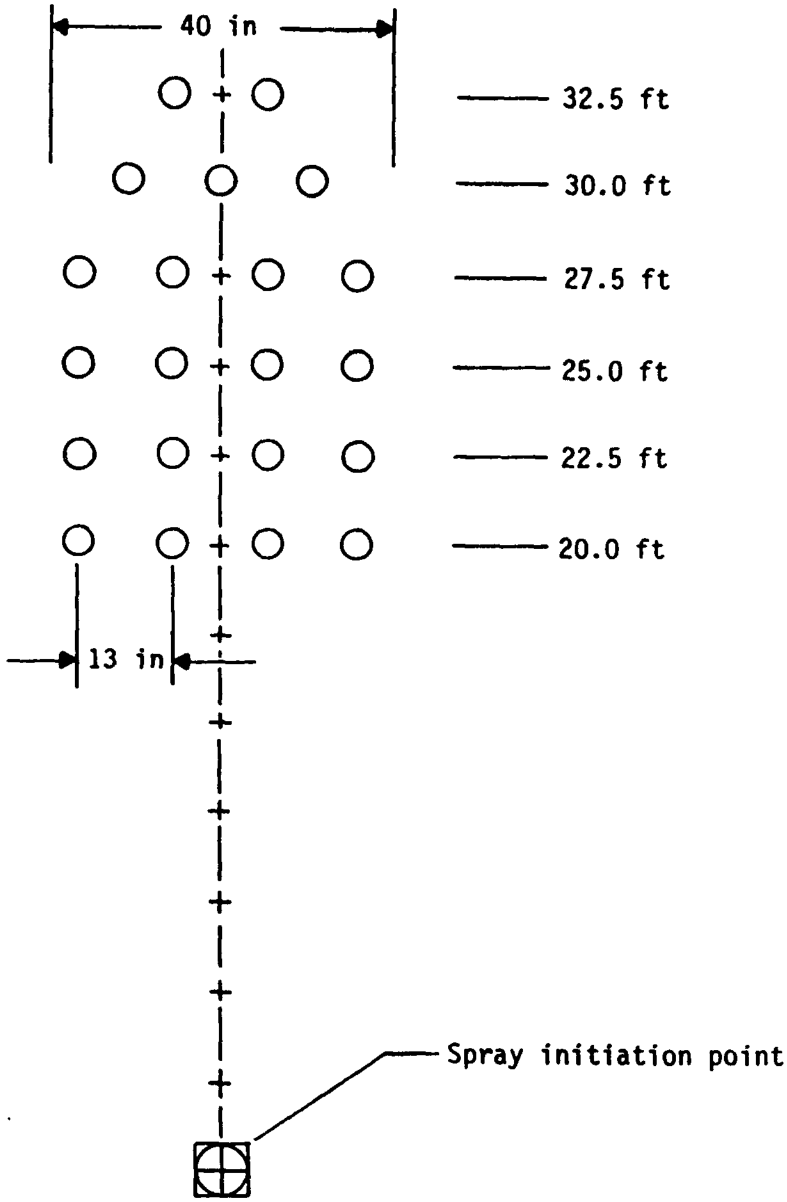

Figure 1. Spray Pattern Test--Ranging/Throw Pattern Layout.

3. Medium-Scale Tests

The medium-scale testing of the prototype units was conducted at Tyndall Air Force Base, Panama City, Florida, on 10 December 1987 to 11 December 1987. Magnesium ingots weighing 3 to 4 pounds each were individually ignited on a fabricated test stand (Figure 2). This stand was designed so that both the medium- and large-scale fire tests could be conducted on the same apparatus. The stand was free-standing and supported a heavy-gauge steel fire pan 4 feet above the ground. The pan was tilted forward to allow the molten magnesium to flow down a metal screen, simulating a running fuel fire. Boralon extinguishing agent was used on all fires.

The same agent filling procedure was followed for each prototype extinguisher. This has been proven as a practical and accurate manual filling procedure. Both agents were poured or pressure-fed into the extinguisher shell (tank) separately and then mixed thoroughly using agitation and the nitrogen charge. Care was taken not to expose the shut-off valve to the TMB agent during filling. The procedure is as follows: (a) The extinguisher shell was weighed and the weight was noted and subtracted when the agent was added. (b) The weight of TMB necessary to give a 70 percent by volume solution was manually measured into a graduated container. This TMB was then poured directly into the extinguisher shell, through a funnel, and the shut-off valve was installed into the extinguisher opening, sealing the TMB from the ambient moisture. (c) A conversion fitting was attached to the shut-off valve and an agent filling hose. The hose was then attached to a standard Halon 1211 storage tank, using the required pressure regulator and safety equipment. The extinguisher was again weighed and the weight was noted and subtracted when the halon was added. The regulator and the shut-off valve were opened; the halon was added until the required weight, determined from density/volume calculations-- was reached, and the shut-off valve was closed. (d) The halon agent hose was disconnected from the shut-off valve, following the required safety procedures, and the extinguisher hose was attached. Dry

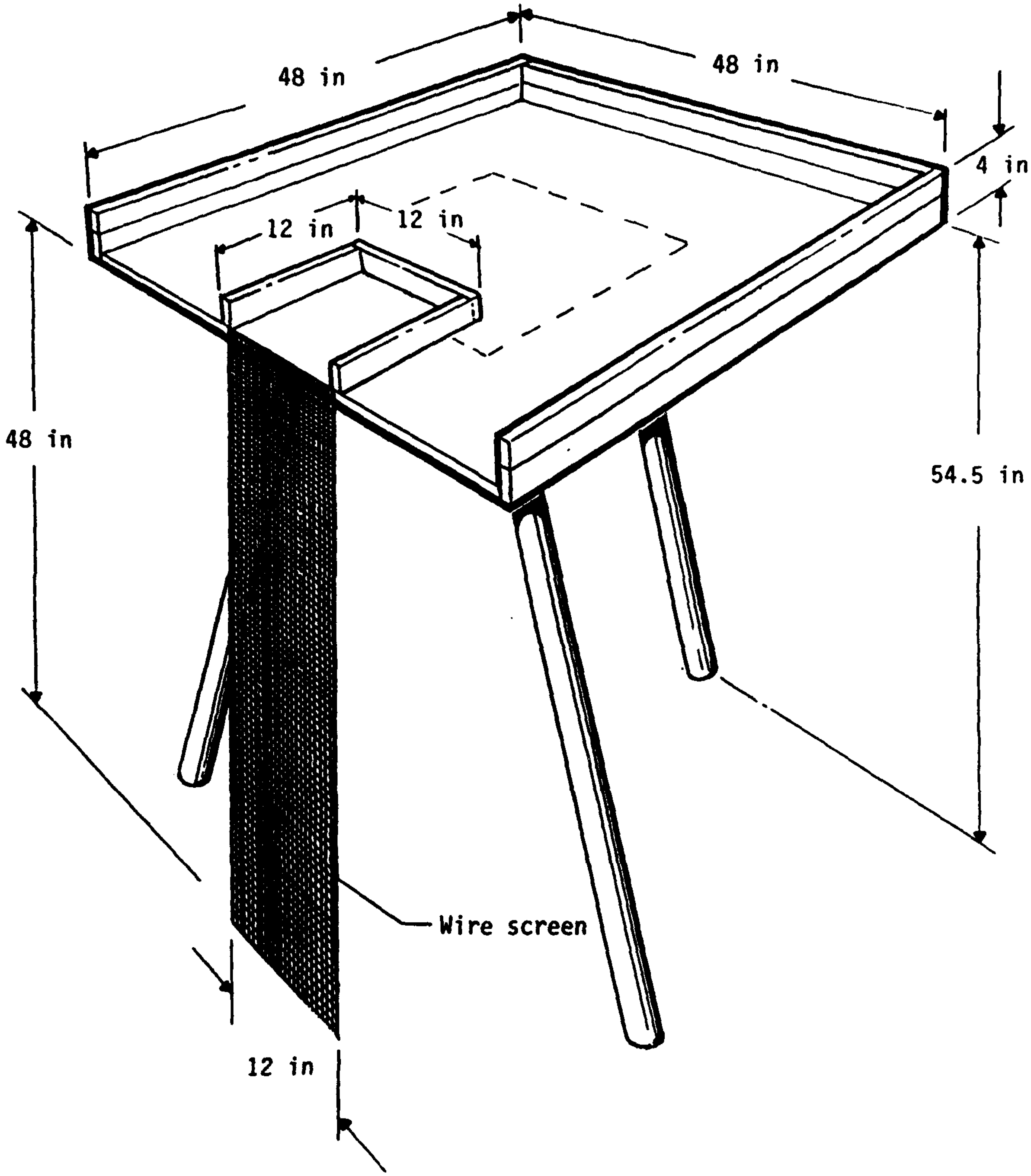

Figure 2. Fire Stand Used for Medium- and Large-Scale Tests.

nitrogen was then used to charge the unit to the desired operating pressure. Testing of the unit showed that, for proper extinguisher performance, the nitrogen should be added to the extinguisher through the shut-off valve. All the halon should be flushed from the extinguisher diptube to prevent the possible reaction of undiluted Halon 1211 with burning metals when the shut-off valve is initially opened.

Manufacturers may develop filling procedures modified from the above instructions. Cooling the agent mixture to a point that both components remain as liquids and pouring both agents into an extinguisher as one liquid mixture could be a practical method. Any agent mixture should be poured directly into the extinguisher shell and not allowed to contact the shut-off valve and its components.

A total of seven tests were completed and the nozzles, test pressures, and agent amounts chosen in the spray pattern tests. The NMERI unit was tested at 200 $lbf/in.^2$, with the Spraying Systems Model Numbers 1560 and 0020 nozzles and with agent amounts ranging from 2 to 2.5 gallons. The MSA unit was tested at 100 $lbf/in.^2$ with the Spraying Systems Model Number 0020 nozzle and 2 gallons of Boralon agent.

The NMERI prototype attained average flow rates of 2.8 gallons/min using the 1560 nozzle and 4.1 gal/min using the Model 0020 nozzle, with a working pressure of 200 $lbf/in.^2$. The unit weighed 50 to 65 pounds when fully charged. The 0020 nozzle, which gives a straight-stream nozzle pattern, worked more effectively against the magnesium fires. The 1560 nozzle, with a 15 degree cone spray pattern, spread the agent over too large an area, and insuffient agent reached the fire. With the straight-stream nozzle, the fire was extinguished rapidly (within 15 to 30 seconds), and most of the agent reached the fire from distances of 12 to 20 feet.

The MSA unit produced a flowrate of 1.6 gallons/min using the 0020 nozzle, a working pressure of 100 lbf/in^2g, and 2 gallons of Boralon agent. The unit weighed 40.0 pounds when fully charged. The unit produced a fine, concentrated stream of agent that disrupted the fire when the agent was applied, causing sparking.

Both units proved to have favorable qualities. The nozzle and agent amount used on the NMERI prototype delivered the most effective throw pattern and provided optimum extinguishment of the magnesium fires. The MSA unit weighed less, improving the mobility of the firefighter. These qualities were then further tested with the large-scale magnesium fire tests. Note that each of these units are prototypes, not finished products.

4. Large-Scale Tests

The large-scale testing of the prototype units was conducted at Tyndall Air Force Base, Panama City, Florida, between 15 and 22 December 1987. Thirteen tests were completed using fires of 15 to 80 pounds of magnesium metal. The NMERI and MSA prototypes and an ANSUL standard halon extinguisher were tested. The Spraying Systems Model 0020 nozzle and other nozzles with larger orifice openings were used in the testing. The fire stand was shortened and leveled at 3 feet from the ground to present a more realistic magnesium fire for the testing. The vertical screen was also removed. The magnesium metal was ignited using a JP-4 and oxygen twin nozzle ignitor system. The system was constructed using 60 feet of 1/4 inch stainless steel tubing remotely connected to the JP-4 and oxygen supplies.

The NMERI prototype proved to be effective when tested against magnesium fires of 50 pounds or less when a nozzle was used with an orifice diameter of 0.1719 inch, an operating pressure of 200 lbf/in^2g, and 3 gallons of Boralon agent were used. An average flow rate of 1.7 gallons/min was acheived using these operating parameters, and the fires were extiguished in an average of 1.64 minutes. Larger fires, containing up to 80 pounds of metal, were also tested. The extinguisher effectively diminished and initially controlled these fires; however, final extinguishment was not acheived. The unit weighed an average of 69 pounds when fully charged with 3 gallons of agent.

The MSA prototype was tested using a Spraying Systems Model 0030 straight-stream nozzle, orifice diameter of 0.141 inch, operating pressure of 100 psig, and 2 gallons of agent. The unit produced a flow rate of approximately 1.0 gallons/min and was acceptably effective against fires containing 15 pounds of magnesium metal. Total extinguishment of larger fires, up to 50 pounds, were beyond the capabilities of the unit. The unit also incorporated a flow-straightener in the nozzle assembly which, while it improved the throw range of the unit, delivered the agent in a narrow stream that disrupted the fire and caused sparking and popping. The unit weighed an average of 39 pounds when fully charged.

The ANSUL unit was filled to its capacity of 2 gallons and charged to its operating pressure of 150 psig. The unit produced a flow rate of 0.85 gal/min and weighed 43.5 pounds when fully charged. This unit could effectively extinguish a 15-pound magnesium fire. Not all of the agent was needed for complete extinguishment. The throw pattern of the nozzle, while effective for halon use, was too disperse for the Boralon agent, and required an unacceptably close approach by the firefighter to achieve total extinguishment. The components of the extinguisher are not Boralon-compatible and several parts of the valve assembly deteriorated during testing.

The NMERI and MSA prototype units were successfully tested, and were shown to be effective against smaller or incipient magnesium fires. Further development of these units, on the manufacturing level, may be needed to produce the optimum unit.

B. RELIABILITY TESTING

1. Regulations

Requirements and regulations of the National Fire Protection Association (NFPA), Underwriters Laboratories Inc. (UL), Department of Transportation (DOT), Compressed Gas Association (CGA), and military standards and specifications from the Navy and Air Force applying to 2.5-gallon handheld extinguishers were consulted to determine the required reliability tests. Several of these regulations were used as guidelines for the testing that was developed and completed. A set of tests was chosen to simulate the operating environment of the extinguisher.

The NFPA has several generalized regulations for handheld, portable extinguishers (References 14 and 15). These regulations apply primarily to classification testing, general maintenance, and safety. No specific reliability tests are recommended.

UL has developed several standards commonly used in industry to control the manufacturing of handheld extinguishers (References 10 and 17-20). Several reliability tests were found that could be adapted for use with a Boralon extinguisher.

The DOT applies its regulations to articles shipped from one destination to another (References 1-13 and 16). Once the unit is delivered and used in the field these regulations no longer apply. These regulations must be considered, however, to ensure that manufacturers of the Boralon extinguisher can ship this product. These regulations are closely referenced and associated with the UL standards. Therefore, tests listed in the most applicable of these regulations were used as guidelines for some of the prototype reliability tests.

The CGA has several standards for cylinder inspection and maintenance that are commonly used in industry (References 21-22). These tests are simple visual and pressurization tests and are referenced in the draft military specification (Appendix A).

Some military standards and specifications have been written for handheld extinguishers (References 3, 23-24). Other specifications and standards apply to extinguisher testing and manufacturing (References 25-27). These are referenced in the draft military specification. The specifications written for handheld extinguishers were used as guidelines in writing the Boralon extinguisher specification.

2. Testing

The tests that were performed were designed to evaluate the NMERI prototype for leakage and unacceptable performance. Some of these tests were patterned after standard DOT, UL, CGA, MIL-STD tests; however, these tests were modified to better meet the requirements of this particular extinguisher. These tests were conducted with the unit charged with Boralon at the operating pressure of 200 lbf/in^2 and are defined in the following paragraphs.

a. System Aging

Age testing of Boralon has been completed and documented (References 1 and 2). Testing with other unit components, such as hoses, fitting seal tape, valve material, metal fittings, etc., has also been completed (References 1 and 2). To determine the long-term aging effects on the complete extinguisher unit and its components, the unit was charged with Boralon at its operating pressure and placed in storage after the temperature effects and vibration tests were completed.

b. Temperature Effects Tests

The operating temperature range of the Boralon agent has already been established (Reference 2). This range, $-22^{o}F$ to $140^{o}F$, fixes the range of testing temperatures for the unit. The unit was subjected to the following 48-hour temperature cycle shock test.

The prototype extinguisher unit was placed in a Westinghouse Model Number FC053P, serial number FSB5132P, electric freezer which maintained a constant temperature of -2^{o}F for of 21 hours. At the end of this period the unit was removed from the freezer and allowed to slowly return to room temperature. Immediately after its removal from the freezer, the unit was checked for dimensional and pressure changes and was leak-tested.

The leak testing was conducted by applying a soap solution to all possible leak points. Threaded joints, couplings, and other fittings were tested. Air bubbles would show leakage. The circumferencial dimensions of the unit were measured at the top and bottom of the unit's cylinder body before and after cold exposure.

No dimensional changes or leaks were found. The pressure of the unit had decreased to 50 lbf/in.^{2} while in the freezer and slowly returned to a pressure of 176 lbf/in.^{2} as the unit warmed to room temperature. After an acclimation period of 5 hours, the prototype unit was placed in the oven.

The prototype unit was placed in a George Koch and Sons, Inc., 230-volt, 3-phase, 60-hertz, electric walk-in drying oven which maintained a constant temperature of 120^{o}F for 21 hours. Immediately upon its removal from the oven, the unit was rechecked for dimensional and pressure changes and possible leakage points. It was then allowed to acclimate before further testing.

c. Stress Test

Several tests are designed to simulate vibrations occuring in various operational environments. The DOT has developed a test procedure that approximates the vibrations occuring during transport by a ground vehicle (Reference 23). In following the requirements of this test, the unit was subjected to a vibration with a double amplitude of 1 inch, allowing the unit to rise off the table approximately 1/4 inch, for 1 hour. The shaker table used for this testing was a FMC Corporation, Type PJ 15, Style 1774, serial number 151PJ 183315, paper jogger. The prototype unit was then leak and discharge tested.

The discharge testing was conducted with the procedures developed and used in the Spray Pattern Tests. The throw range and throw pattern was observed and all changes from the original flow or operating characteristics were noted.

SECTION IV

TESTING OF FINAL DESIGN

The final design of the extinguisher was based on the information obtained from the prototype testing. The design specified a stored-pressure unit type, sealed with a frangible plug or rupture disk which was activated when the handle was depressed. The unit was required to have a fill ratio of 75 percent agent to 25 percent nitrogen pressure head at 200 lbf/in^2 and to be filled with at least 2 gallons of Boralon. Two manufacturers, F.P.S. International, Inc., and Metalcraft, Inc., supplied units that met these criteria.

The F.P.S. International, Inc., unit incorporated a frangible plug design. The plug sheared off horizontally when the handle mechanism was depressed. The handle assembly was also capable of intermittent discharge, allowing the flow of the agent to be stopped when the handle was released. The unit was intended for a one-time use; however, refilling and reuse of the extinguisher is possible if the entire unit is thoroughly flushed with water and dried immediately after use.

The Metalcraft, Inc. unit was sealed by a splined rupture disk which was punctured by a plunger when the extinguisher handle was depressed. It was also designed for intermittent discharge and one-time useage; however, refilling and reuse are possible.

The F.P.S. International, Inc., unit was tested on 20-27 May 1988. The unit was charged with 2 gallons of Boralon at 200 lbf/in^2 with the required fill ratio. In one test, a 30-pound magnesium fire was successfully extinguished in approximately 15 seconds by the unit, using only 0.82 gallons of agent. In the final testing, a 50-pound magnesium fire was extinguished with 1.4 gallons of agent in 17.5 seconds. This unit was demonstrated at Tyndall Air Force Base.

The 2-gallon capacity of each of these units should be sufficient to combat typical magnesium fires at higher altitudes. Bases located at sea level could require two 2-gallon extinguishers. Investigations showed that most aircraft fires occur when overheated brakes ignite. Magnesium metal alloys are used in the construction of these and other mearby parts, such as wheels. The parts range in weight from 5-50 pounds and average about 30 pounds.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

Several handheld extinguisher design concepts were considered. Rupture disk systems allowing hermetic storage of the Boralon agent could be externally pressurized or stored under pressure. These systems require expendable rupture disks to be fitted on the extinguisher tank. These disks are ruptured by pressure from an externally mounted carbon dioxide cartridge, by an electronically actuated explosive device, or manually. The first two rupture options are costly and could make the extinguisher unmanageable. Manually ruptured activation of a stored pressure unit is a feasible final option. A manually activated plunger punctures the splined rupture disk when the unit is used. An extinguisher sealed with a frangible plug instead of a splined rupture disk is also feasible. The final extinguisher design should incorporate either of these two designs to produce a sealed, stored-pressure unit, activated by pressing the handle downward when used. The stored pressure concept that incorporated the use of a shut-off containment valve was chosen as the most economical and maintainable extinguisher design for prototype testing purposes.

The NMERI prototype unit proved to be effective against magnesium fires of up to 50 pounds or less when a 0.1719-inch diameter nozzle, a 200-lbf/in.^{2} operating pressure, and 3 gallons of Boralon agent were used. The extinguisher produced flow rates of 1.7 gal/min and effectively extinguished fires in an average of 1.6 minutes. The unit could also effectively diminish and intially control magnesium fires of up to 80 pounds, however, final extinguishment was not acheived.

The MSA prototype operated best when using a 0.141-inch nozzle, a 100-lbf/in.^{2} operating pressure, and 2 gallons of Boralon agent. The unit produced flowrates of 1.0 gal/min and was marginally effective against magnesium fires of 15 pounds. The unit incorporated a flow-straightener in the nozzle assembly that produced an agent stream that disrupted the fire and caused undesirable popping and sparking.

The standard ANSUL halon unit was effective against 15-pound magnesium fires. The nozzle design, however, produced a throw pattern that was too disperse for good fire control. The ANSUL unit was also constructed of materials that were incompatible with Boralon.

The NMERI prototype was tested to determine its reliability. Temperature shock, vibration stress, and aging tests were successfully completed.

A final extinguisher design which includes two options was developed using the information gained from the prototype testing. This unit was a sealed, stored-pressure extinguisher which uses either a frangible plug or a splined rupture disk as a seal. The unit is activated by pressing the extinguisher handle downward and either shearing the frangible plug or puncturing the rupture disk.

An extinguisher with the frangible plug seal successfully extinguished 30- and 50-pound magnesium fires. During these tests, the fires were extinguished in 15-17.5 seconds using 0.8-1.4 gallons of agent. This agent amount should be doubled when used at sea level.

The extinguisher can be classified as either a reuseable/refillable or disposable unit. In either case, the handle/nozzle assembly could be thoroughly flushed with water and dried after each use and reused.

The extinguisher cylinder should be manufactured of either mild steel or aluminum but should be able to obtain a DOT rating (Reference 13) requiring a hydrostatic pressure test of three times the operating pressure.

No safety pressure relief device is required; however, a pressure gage is specified. This gage could be silicone oil-filled to prevent the agent from clogging the gage.

A draft military specification (Appendix A) was prepared to govern this development.

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12. Specification 4B: Welded and Brazed Cylinders, Title 49-Transporation, Code of Federal Regulations, Department of Transportation (DOT), 178.50, May 1987.

13. Limited Quantities of Compressed Gases - Fire Extinguishers, Title 49-Transporation, Code of Federal Regulations, Department of Transporation (DOT), 173.306(c), May 1986.

14. Standard for Portable Fire Extinguishers, NFPA 10-1984, National Fire Protection Association, 1984.

15. Standard for Portable Fire Extinguishers, Enabling Act, NFPA 10L-1980, National Fire Protection Association, 1980.

16. Qualification Maintenance and Use of Cylinders - Pressure Relief Valves, Title 49-Transporation, Code of Federal Regulations, Department of Transporation (DOT), 173.34, Part (5) (d), May 1987.

17. Dry Chemical Fire Extinguishers, UL 299-82, Underwriters Laboratories, 1982.

18. 2-1/2-Gallon Stored Pressure Water Type Fire Extinguishers, UL 626-82, Underwriters Laboratories, 1982.

19. Rating and Fire Testing of Fire Extinguishers, UL 711-79, Underwriters Laboratories, 1979.

20. Factory Follow-up on Third Party Certified Portable Fire Extinguishers, UL 1803-86, Underwriters Laboratories, 1986.

21. Standard for Visual Inspection of Compressed Gas Cylinders (Steel), CGA C-6-1975, Compressed Gas Association, 1975.

22. Standard for Hydrostatic Testing of Steel Cylinders, CGA C-1-1975, Compressed Gas Association, 1975.

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25. Military Standard, MIL-STD-810D, Environmental Test Methods and Engineering Guidelines, 19 July 1983.

26. Military Standard, MIL-STD-210B, Climatic Extremes for Military Equipment, 15 December 1973.

27. Military Specification, MIL-S-901C(NAVY), Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for, 5 September 1963.

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APPENDIIX A

DRAFT MILITARY SPECIFICATION
HANDHELD DELIVERY SYSTEM FOR
MODIFIED BORON TYPE FIRE EXTINGUISHING AGENT

1. SCOPE

1.1 Scope. This specification covers the requirements for a 2-gallon agent capacity handheld Boralon fire extinguisher of the sealed, stored-pressure type. It is capable of extinguishing magnesium fires and is activated by pressing the handle downward.

2. APPLICABLE DOCUMENTS

2.1 Government Documents.

2.1.1 Specifications and Standards. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of investigation for bids or request for proposal shall apply.

SPECIFICATIONS

MILITARY

MIL-P-116	Preservation-Packing, Methods of
MIL-B-38741	Bromochlorodifluoromethane, Technical
MIL-F-2261A	Fire Extinguishing Agent, Liquid, Boron-Type, for Metal Fires
MIL-B-26195	Box, Wood, Cleated, Skidded, Load Bearing Base

MIL-F-XXXX	Fire Extinguishing Agent, Modified Boron-Type, for Metal Fires

FEDERAL

BB-N-411	Nitrogen, Technical
PPP-B-601	Boxes, Wood, Cleated Plywood
PPP-B-621	Box, Wood, Nailed and Lock-Corner
PPP-B-636	Boxes, Shipping, Fiberboard
PPP-B-640	Boxes, Fiberboard, Corrugated, Triple-Wall

STANDARDS

MILITARY

MIL-STD-100	Engineering Drawing Practices
MIL-STD-105	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Indentification Marking of U.S. Military Property
MIL-STD-143	Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-210B	Military Equipment, Climatic Extremes for

MIL-STD-808	Finishes, Protective, and Codes, for Finishing Schemes for Ground and Ground Support Equipment
MIL-STD-810D	Engineering Guidelines, Environmental Test Methods and
MIL-STD-831	Test Reports, Preparation of
MIL-STD-889	Dissimilar Metals
MIL-STD-1186	Cushioning, Anchoring, Bracing, Blocking and Waterproofing; with Appropriate Test Methods

FEDERAL

FED-STD-H28	Screw Thread Standards for Federal Services
FED-STD-H28/2	Unified Thread Form and Thread Series for Bolts

2.1.2 Other Government documents and publications.

DEPARTMENT OF TRANSPORTATION

Code of Federal Regulations, Title 49 - Transportation
Part 173.306(c)

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C.)

2.1.3 Drawings.

NEW MEXICO ENGINEERING RESEARCH INSTITUTE

XXXX-XXXX Handheld Fire Extinguisher For Metal Fires - Final Design

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 <u>Other Publications</u>. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation for bids or requests for proposal shall apply.

UNDERWRITERS LABORATORIES, INC. (UL)

UL 711-79 Fire Extinguishers, Rating and Fire Testing of

UL 1093-83 Fire Extinguishers, Halogenated Agent

(Application for copies should be addressed the Underwriters Laboratories, Inc., 207 East Ohio Street, Chicago, IL 60611.)

UNIFORM CLASSIFICATION COMMITTEE AGENT

Uniform Freight Classification Ratings, Rules and Regulations

(Application for copies should be addressed to the Uniform Classification Committee Agent, Tariff Publication Officer, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

COMPRESSED GAS ASSOCIATION, INC. (CGA)

C-1-1975	Steel Cylinders, Standard for Hydrostatic Testing of
C-6-1975	Compressed Gas Cylinders, Standard for Visual Inspection of

(Application for copies should be addressed to the Compressed Gas Association, Inc., 500 Fifth Avenue, New York, NY 10110.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 10-1980	Portable Fire Extinguishers, Standard for
NFPA 10L-1980	Portable Fire Extinguishers, Enabling Act, Standard for

(Application for copies should be addressed to the National Fire Protection Association, Battery March Park, Quincy, MA 02269.)

2.3 Order of Precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence.

3. REQUIREMENTS

3.1 Preproduction. This specification makes provisions for preproduction testing.

3.2 Selection of standards and specifications. Standards and specifications for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

3.3 Fire extinguishing agent requirements. Where specified, the agent shall be composed of a mixture of trimethoxyboroxine and bromochlorodifluoromethane. The agent shall be 70 percent (± 2 percent) by volume trimethoxyboroxine and 30 percent (± 2 percent) by volume bromochlorodifluoromethane. The bromochlorodifluoromethane shall conform to MIL-B-38741. The resulting mixture shall conform to MIL-F-XXXX.

3.4 Parts and materials of construction. Materials shall be as specified herein. Materials not specifically covered by this or applicable specifications shall be suitable in every respect and of good quality. Wood shall not be used in construction.

3.4.1 Metals. Unless otherwise specified herein, metal parts and components used in the fabrication of this unit shall be corrosion-resistant steel or brass.

3.4.1.1 Dissimilar metals. Unless protected against electrolytic or other types of corrosion, dissimilar metals shall not be used in intimate contact with each other. Dissimilar metals are defined in MIL-STD-889.

3.4.2 Non-metals. The use of non-metallic materials shall be limited to those which are compatible with the fire extinguishing agent for parts intended for extended use. Materials that have shown a favorable compatibility include tetrafluoroethylene (TFE) fluorocarbon polymers, acetal resin, and polyvinyl resin.

3.4.3 Design and construction. The extinguisher shall be a stored pressure type which is sealed by a frangible plug or splined rupture disk. The completed extinguishing unit shall be so designed and constructed that the seal will not loosen during normal service. The unit shall be capable of withstanding the stresses incident to shipping, storage, handling, and usage. The unit shall also provide ease of operation and adhere to all applicable safety codes.

3.4.4 Functional design. The extinguishing unit shall be so designed and constructed so that can be easily and safely stored on current government fast-response fire vehicles. The unit shall be activated by depressing the handle, removing or puncturing the seal, when useage is required.

3.4.5 Reliability. The reliability of the extinguishing unit will be demonstrated by successful completion of the reliability tests specified herein.

3.4.6 Maintainability. The extinguishing unit shall be designed and constructed in such a manner that:

a. A minimum number of parts are used in its construction. These parts shall be positioned for ease of inspection and maintenance.

b. Readily available standard tools and equiptment can be used for maintenance of the unit. The parts, where possible, shall be of a common size to allow maintenance with a minimum number of tools.

3.4.7 Workmanship. The extinguishing unit, including all parts and accessories, shall be fabricated and finished in a quality manner. Particular attention shall be given to quality control concerning blemishes, defects, burrs, and sharp edges of manufactured parts; marking of parts and assemblies; quality of soldering, welding, brazing, riveting, and painting; alignment of parts; and tightness of assembly screws, bolts, et cetera.

3.4.8 Overall unit dimensions. The extinguishing unit shall have a total height of approximately 27 inches and be 6.5 inches in diameter.

3.4.9 Finishes and protective coatings. The tank of the extinguishing unit shall be cleaned, treated, and painted in accordance with MIL-STD-808. Brass and corrosion resistant steel fittings may be painted provided that such painting is in compliance with these standards.

3.4.10 Part numbering of interchangable parts. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeble. The item identification and part numbering requirements of MIL-STD-100 shall govern the manufacturer's part numbers and changes thereto.

3.4.11 Extinguisher shell (or tank). The extinguisher tank shall be designed in accordance with the Code of Federal Regulations, Title 49 - Transportation, Part 173.306(c), to operate safely at a working pressure of 200 psi. The welded seams on the tank shall not exhibit agent leakage rates that exceed 0.6 ounces per year per seam. Any valves that are attached to the tank shall not exhibit leakage rates exceeding 10 ounces per year per valve.

3.4.12 Handle Assembly. The handle assembly shall be constructed with a plunger or shearing mechanism that punctures/removes the extinguisher seal when the handle is depressed. This mechanism shall also be designed to allow intermittent flow capabilities. Openings within the assembly through which the agent will flow shall not be smaller than 0.375 inches.

3.4.13 Diptube. The diptube shall be constructed of thin-wall metal tubing and shall be securely fastened the inside the throat of the tank. The diptube shall also be constructed at a length such that maximal agent usage is possible.

3.4.14 Pressure gauge. The extinguishing unit shall be equipped with a durable pressure gauge with a 1.5 inch face, 1/8 inch rear mount threaded fitting, and an indicated charge pressure of 200 psi. The gauge shall be of the bourdon tube type with the bourdon tube filled with silicone oil to prevent clogging of the gauge. The gauge shall be labelled "for Boralon use only".

3.4.15 Discharge hose. The discharge hose shall be a standard fire extinguisher hose that is at least 23 inches in length. The hose shall have a burst pressure of not less than two times the working pressure of the tank, or 400 psi. The hose shall be fitted with a permanent nozzle having an initial opening diameter of 0.21 inches and a final diameter of 0.55 inches. The nozzle shall be approximately 2.0 inches in length. The hose shall be attached to the handle assembly in such a manner so that it is easily removable. A restraining clip should be mounted on the outside of the tank to safely store the hose in a readily accessible position.

3.4.16 Mounting Bracket. The mounting bracket shall be made of heavy steel and shall be designed to last the life of the extinguisher. The bracket shall be designed to securely anchor the extinguisher around the middle and bottom of the unit. The bracket shall be able to withstand the service vibrations that it will be subjected to.

3.4.17 Markings.

3.4.17.1 Identification of product. Equipment, assemblies, and parts shall be marked in accordance with MIL-STD-130.

3.4.17.2 Additional markings. In addition to the markings specified in 3.4.17.1, a plate shall be attached to one side of the tank (See Figure A-1). The serial number of the tank, gross weight of the tank, and DOT rating shall be clearly stamped on the plate.

3.5 Unit performance. Performance requirements of the extinguishing unit shall be based on operation at sea level at temperatures of $75^{o}F$ ($\pm 5^{o}F$).

3.5.1 Discharge of agent. The extinguisher shall exhibit the following characteristics when discharging the agent at normal operating pressure through the specified agent discharge hose.

a. Discharge time of not less than 40 seconds for entire extinguisher load. This discharge shall be timed from the initiation of agent flow till nitrogen pulsations occur.

b. Effective discharge of not less than 95 percent of the agent capacity without nitrogen pulsations.

c. Throw range of 12 feet minimum as measured from the tip of the nozzle to the leading edge of the discharge pattern without assist from downwind conditions.

d. Discharge rate of not less than 0.5 lbs/s under normal operating conditions.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of tests. The inspection and testing of the extinguisher unit shall be classified in two categories consisting of:

a. Preproduction testing.................................See 4.4

b. Quality conformance tests.............................See 4.5

4.3 Test conditions.

4.3.1 Preparation for testing. All extinguishers submitted for testing shall contain all specified components and shall be completely assembled and properly adjusted and serviced for immediate operation.

4.3.2 Test agent. The extinguisher testing agent shall conform to the agent description in Section 3.3 of this specification.

4.3.2.1 Agent filling precautions. The extinguisher shall be filled with not less than 2 gallons of the agent specified in Section 3.3. Precautions for filling the extinguisher shall be as follows:

a. All parts of the extinguisher, including valves, fittings, hose, nozzle assembly, and tank shall be clean and free of moisture. Precautions shall be taken to ensure that the agent does not come in contact with moisture during the filling operation.

b. The extinguisher must be filled in a manner that flushes all liquid bromochlorodifluoromethane out of the diptube.

c. The fill ratio of agent to nitrogen pressure shall be 75% agent to 25% pressure head.

4.3.3 Test observations. The extinguisher unit shall be monitored throughout all specified testing for the following faults which shall cause the unit to be rejected:

a. Failure to conform to design and performance requirements specified herein.

b. Unaccountable leakage or associated pressure loss in the extinguisher tank.

c. Misalignment of parts or components caused by testing which affects the performance of the extinguishing unit.

4.4 Preproduction testing.

4.4.1 Testing. All preproduction testing shall conform to Code of Federal Regulations, Title 49 - Transportation, Part 173.306(c).

4.4.2 Test report. A test report shall be prepared in accordance to MIL-STD-831 after completion of the preproduction tests.

4.4.3 Reliability and maintainability information. The following information shall be included as an appendix to the test report:

a. All system failures or any servicing or repairs that were required as the result of the testing shall be recorded as well as time, place, and location of the failure occurrance. Test conditions at the time of the testing period when failure occurred shall also be recorded.

b. A list of all personnel present when the failure occurred.

c. A summary of the engineering failure analysis performed after the failure to determine the cause of failure.

d. A summary of the engineering correctional analysis and design modifications that were completed to correct the cause of the unit failure.

4.5 Quality conformance tests. The quality conformance tests shall conform to Code of Federal Regulations, Title 49 - Transportation, Part 173.306(c) and selected requirements from Underwriters Laboratories (UL) 1093-83, Halogenated Agent Fire Extinguishers. In these wording of these tests, the word halon should be replaced with Boralon. The UL tests are as follows:

a. Section 23 - Fire Tests

b. Section 24 - Pull Pin Tests

c. Section 35 - Vibration Tests

d. Section 36 - Roadability and Rough Usage Tests

e. Section 37 - Handle and Mounting Device Test

f. Section 42 - Burst Strength Test - Gauges and Indicators

g. Section 43 - Overpressure Test - Gauges

h. Section 44 - Impulse Test - Gauges

i. Section 47 - Gaskets and "O" Rings Tests

j. Section 50 - Salt-Spray Corrosion Test

k. Section 51 - One-Year Time Leakage Test

l. Section 52 - Nameplate Exposure Test

m. Section 53 - Nameplate Adhesion Test

n. Section 54 - Nameplate Abrasion Test

o. Section 55 - Nameplate Removal Test

In addition to these tests, a temperature cycling test will be required. In this test, the fully charged extinguisher shall be exposed to a minimum temperature of -22°F and a maximum temperature of 140°F. The unit shall be conditioned at the minimum temperature for 24 hours, then the maximum temperature for 24 hours, then again at the minimum temperature for 24 hours. The unit is then conditioned at $70^{o}F$ for 24 hours and discharged. Not less than 90 percent (by weight) of the total agent capacity shall be discharged after the temperature cycling test is complete.

4.6 Inspection of preparation for delivery. Preservation, packaging, and marking for shipment and storage shall be inspected to determine conformance to the requirements of Section 5.

5. PREPARATION FOR DELIVERY

5.1 Preservation and packaging. The extinguishing unit shall be prepared for shipping according MIL-P-116, Method III. The unit shall be assembled and shall be adequately secured to prevent movement and damage in accordance with MIL-STD-1186. Exposed gauges, controls, and similar items shall be wrapped with a waterproof barrier and taped with waterproof tape. All openings shall be closed with plugs, caps, or waterproof barrier and tape.

5.2 Preservation. Preservation shall be Level A or C as specified. Should Level B be specified, Level A shall apply.

5.2.1 Level A. Each extinguisher unit shall be individually protected in accordance with method III of MIL-P-116. Unit containers shall conform to PPP-B-636 class weather resistant type CF or SF with style selection optional to the supplier. Containers shall be closed in accordance with method V of the appendix to the container specification.

5.2.2 Level C. Each extinguisher unit shall be individually protected as specified for level a except that unit containers may be of the domestic class and closure may conform to method I in accordance with the appendix to the container specification.

5.3 Packing. Packing shall be Level A or C as specified. Should Level B be specified, Level A shall apply.

5.3.1 Level A. Extinguisher units preserved as specified in 5.5 shall be packed in wood cleated plywood boxes conforming to MIL-B-26195, Type II, Style A, Class I.

5.3.2 Level C. Level C shall be the same as Level A except the container shall be Type I and the container superstructure may be attached by nailing in lieu of lag bolts.

5.4 Markings. In addition to the markings specified in 3.4.18 and any special markings required (see 6.2), marking for shipment shall be in accordance with MIL-STD-129.

6. NOTES

6.1 Intended use. The extinguisher unit is intended for use with the modified boron-type fire extinguishing agent for magnesium fires specified in MIL-F-XXX by qualified fire fighting personnel. It shall be used to control and extinguish magnesium fires.

6.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of specification.

b. Location and conditions for preproduction testing.

c. Level of preservation and packaging required (see 5.2).

d. Level of packing required (see 5.3).

e. Additional markings if required (see 5.4).

S/N ______________________________

Gross Weight ________ pounds

DOT _______ Rating

MAGNESIUM FIRE EXTINGUISHER

In accordance with

MILITARY SPECIFICATION MIL-A-

This metal fire extinguisher is for use by qualified fire fighting personnel in the control and extinguishment of magnesium fires.

Agent performance may be affected if used below -25°F.

Avoid exposure to moisture.

Once filled with agent this system is for one-time use only. Do not use if the system has been previously charged and agent dispensed.

This system shall only be refilled by original equipment manufacturer.

Figure A-1. Marking for Magnesium Fire Handheld Extinguisher.

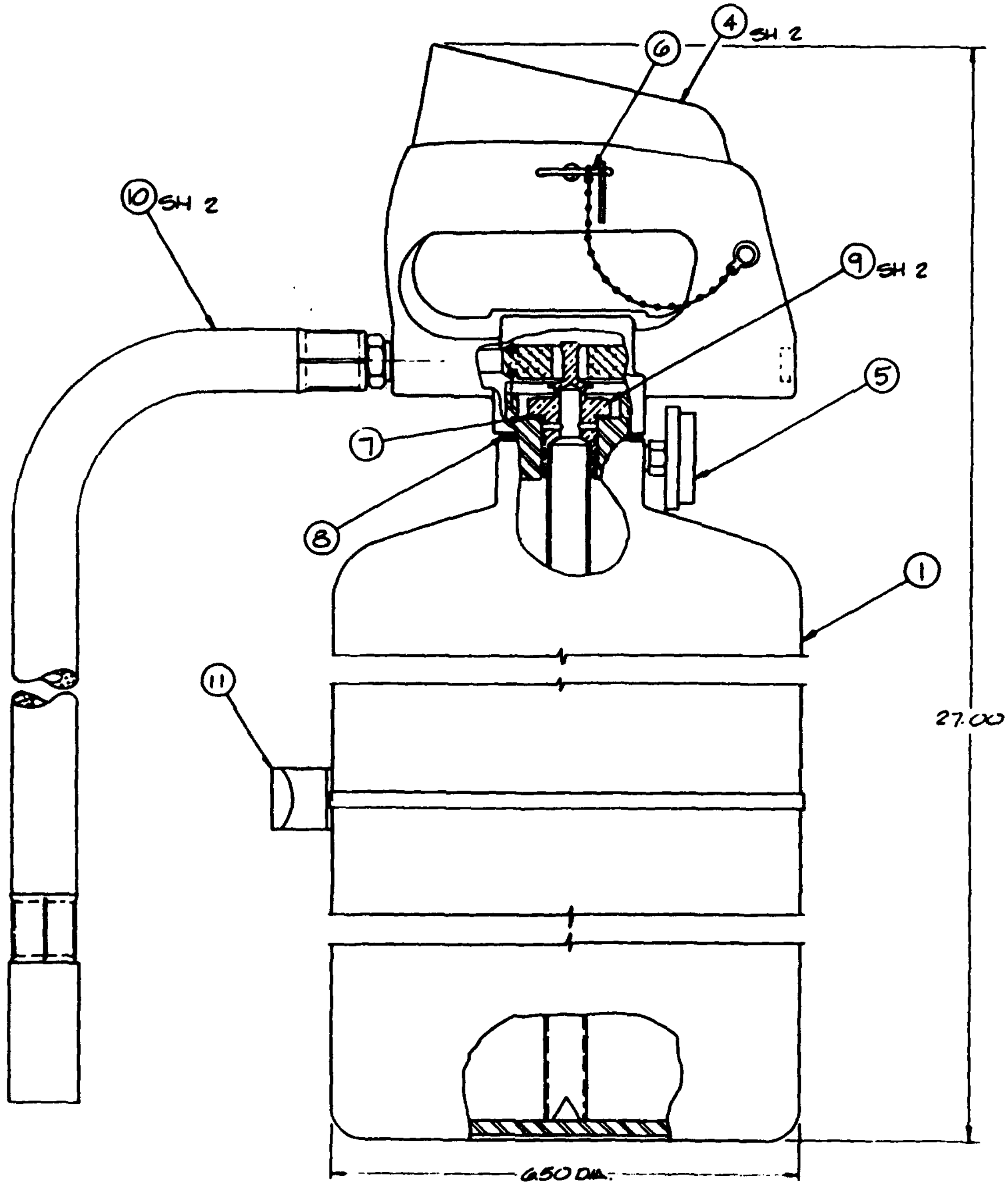


Figure A-2. Option 1 - Frangible Plug Design.

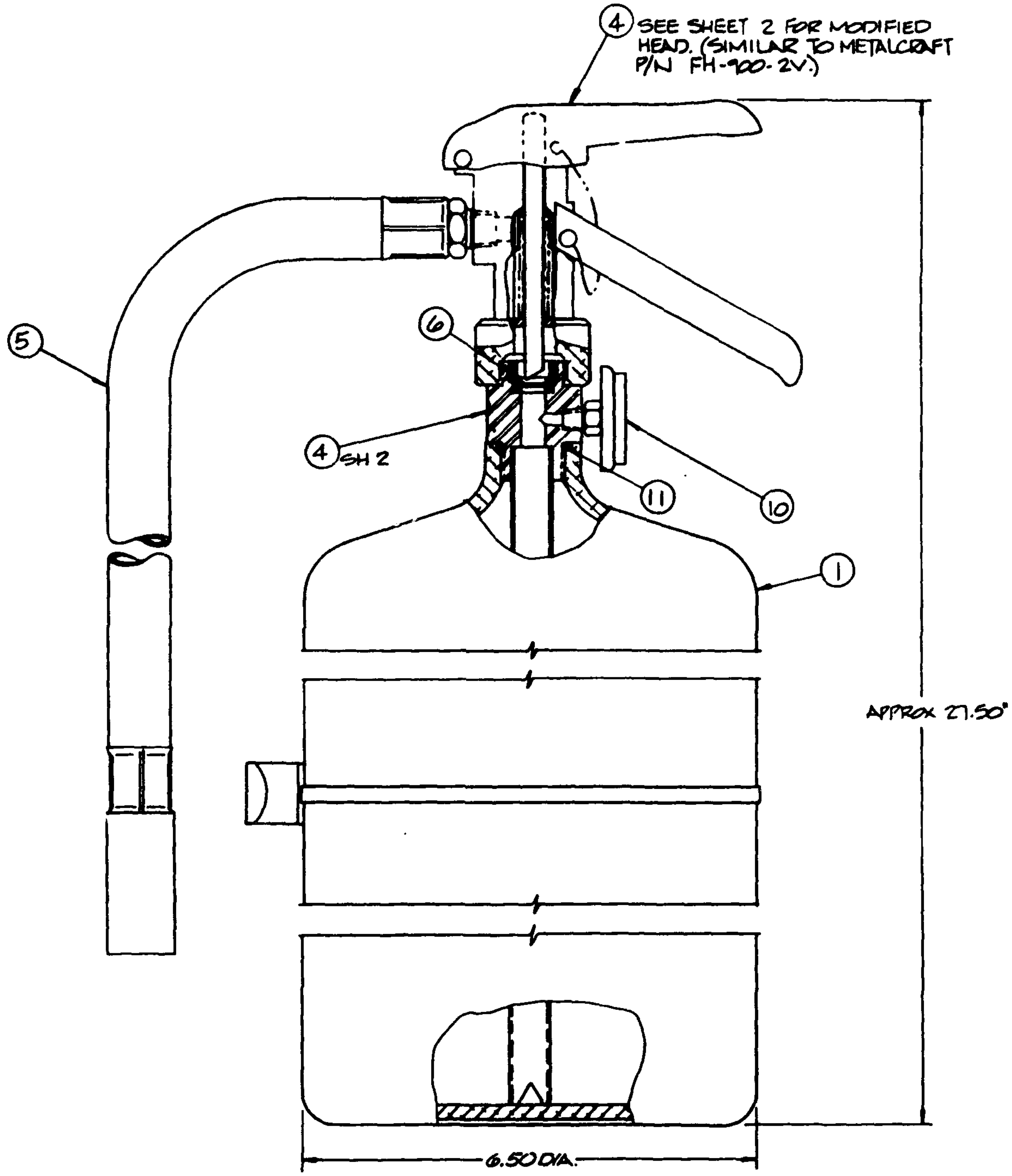


Figure A-3. Option 2 - Splined Rupture Disk.

11	1	40-0288	HOSE RING & CLIP	NOTE 1	
10	1	40-0235	HOSE ASSEMBLY	NOTE 1	SH 2
9	1	40-0233	DIP TUBE ASSEMBLY	NOTE 1	SH 2
8	1	40-1025	'O' RING	NOTE 1	
7	1	40-1010	COPPER WASHER	NOTE 1	
6	1	40-0217	LOCK PIN ASSEMBLY	NOTE 1	
5	1	40-1150	PRESSURE GAUGE	NOTE 1	
4	1	40-0230	HEAD ASSEMBLY, NO. 132	NOTE 1	SH 2
3					
2					
1	1		SEAMLESS CYLINDER, 630 IN³ CAP.		
ITEM	QTY	PART NO.	DESCRIPTION	SPEC.	REF.
LIST OF MATERIAL					

Option 1

11	1		"O" RING		
10	1		PRESSURE GAUGE		
9					
8					
7					
6	1	FH-900-5	CYLINDER SEAL ASS'Y.	NOTE 2	
5	1		HOSE ASS'Y.		
4	1		ADAPTER W/DIP TUBE	BRASS	SH 2
3	1		OPERATING VALVE		
2					
1	1	1XB6804	SEAMLESS CYLINDER, 20#	NOTE 1	
ITEM	QTY	PART NO.	DESCRIPTION	SPEC.	REF.
LIST OF MATERIAL					

Option 2

Figure A-4. List of Materials - Options 1 and 2.

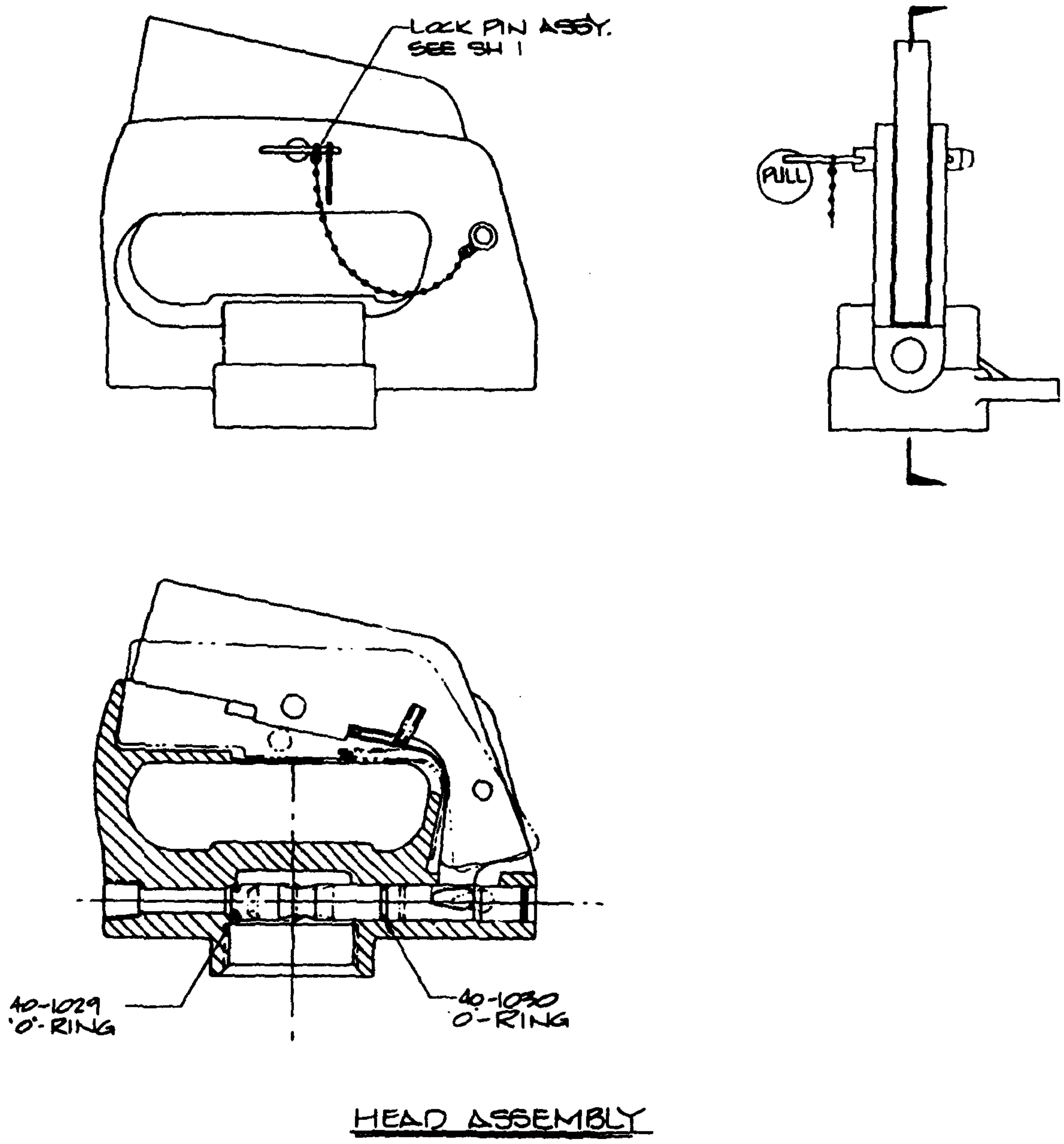


Figure A-5. Detail A - Option 1.

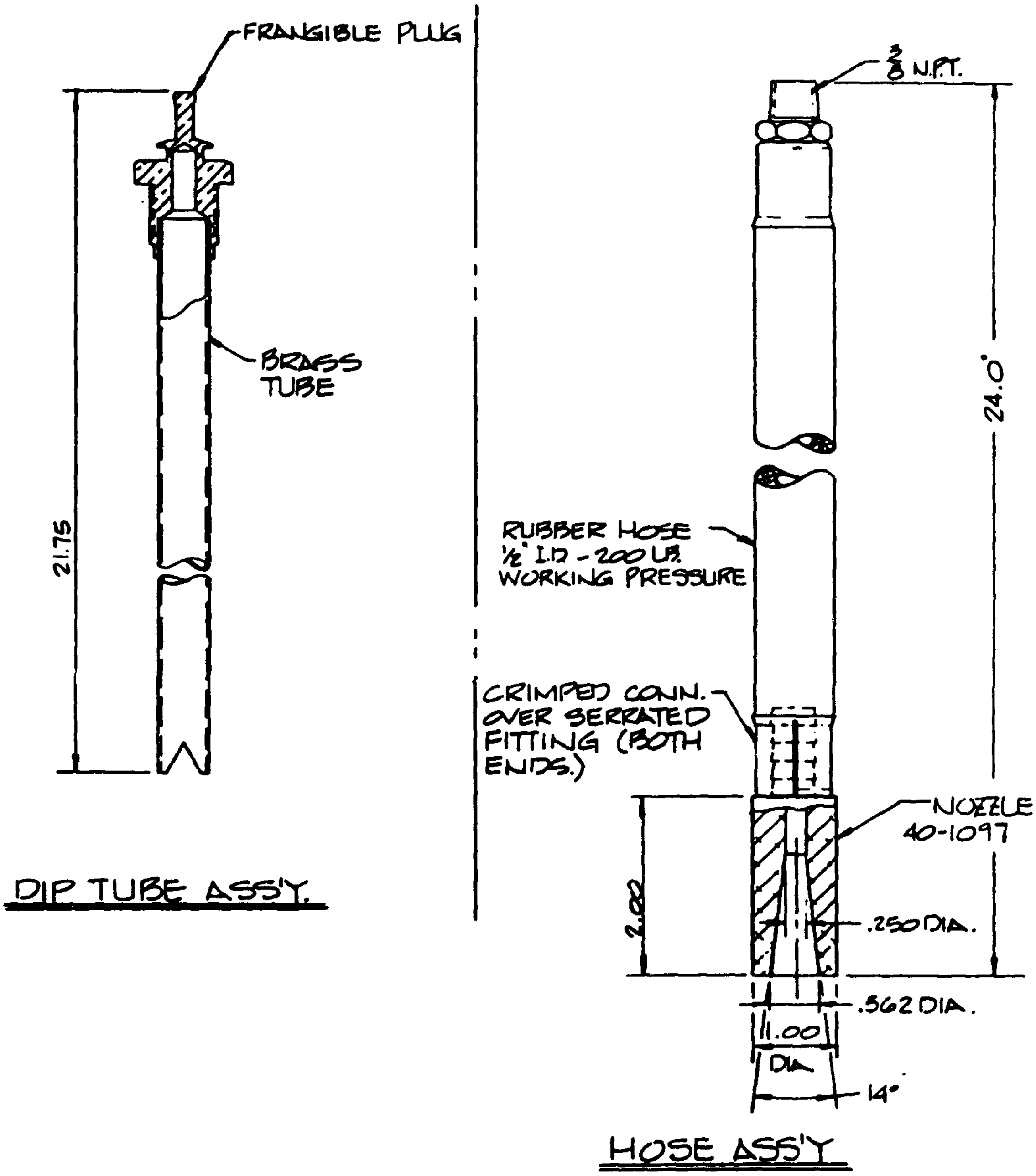
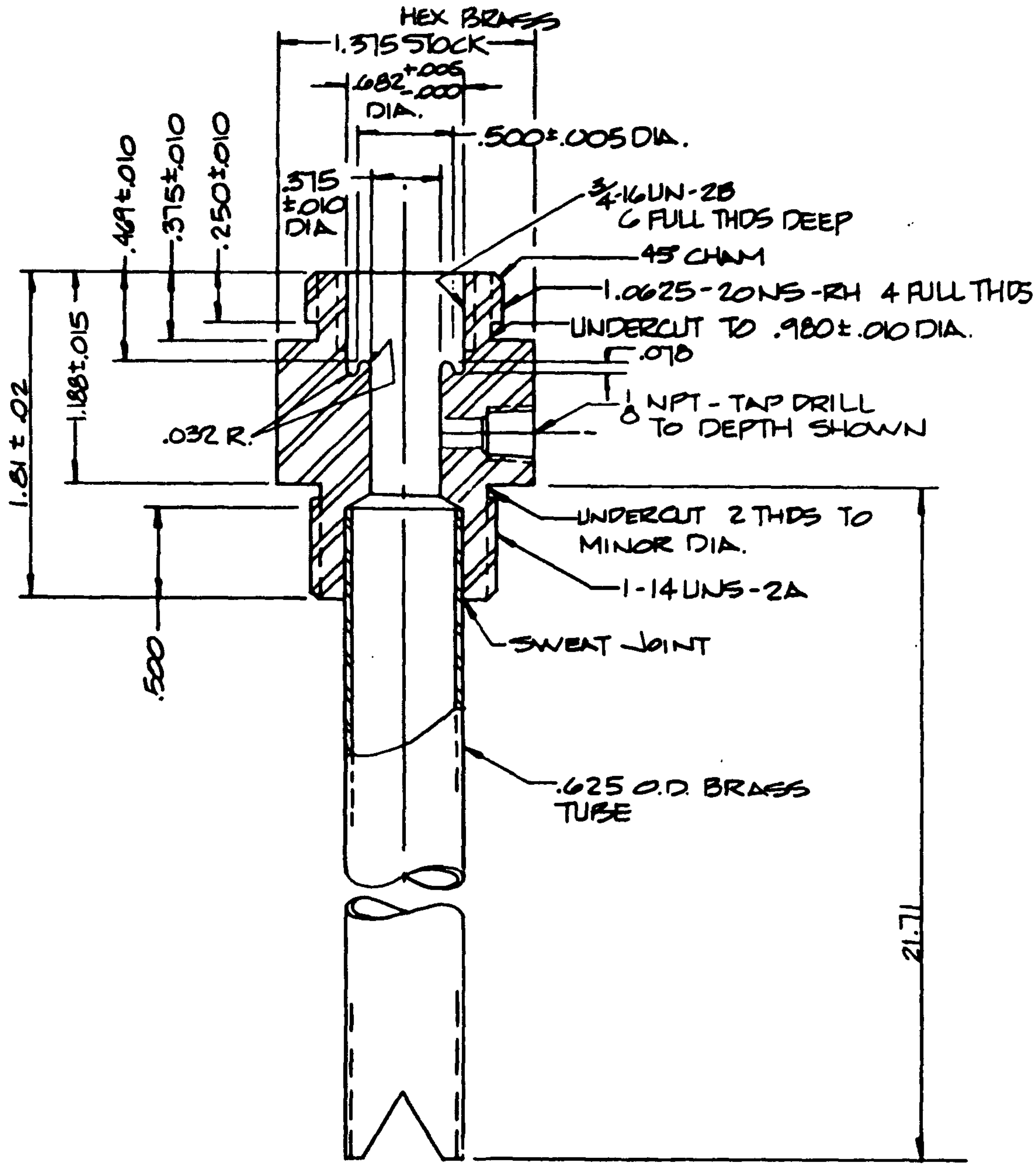
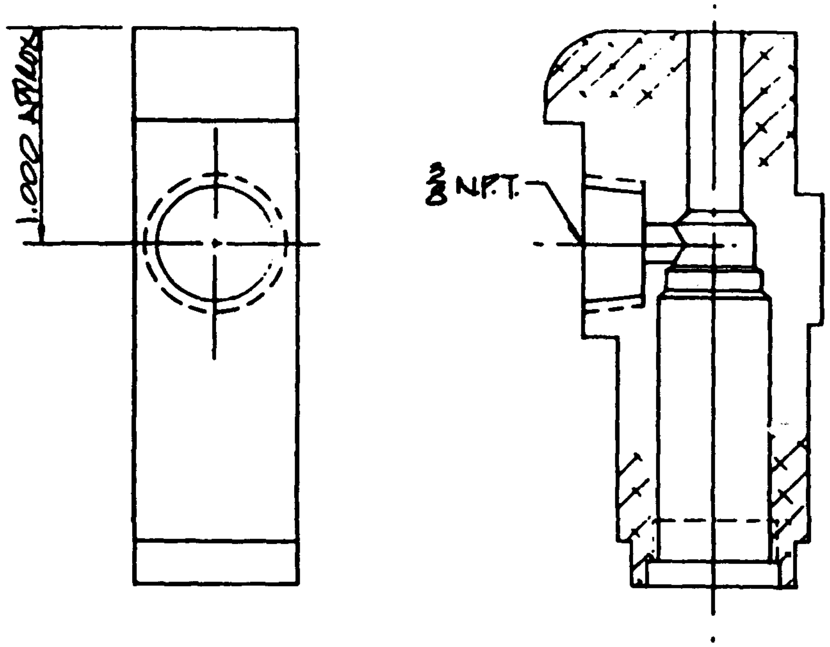


Figure A-6. Detail B - Option 1.



ADAPTER W/ DIP TUBE

Figure A-7. Detail A - Option 2.



HEAD (SIMILAR TO P/N S-70002)

Figure A-8. Detail B - Option 2.

APPENDIX B

PROTOTYPE DESIGN DRAWINGS

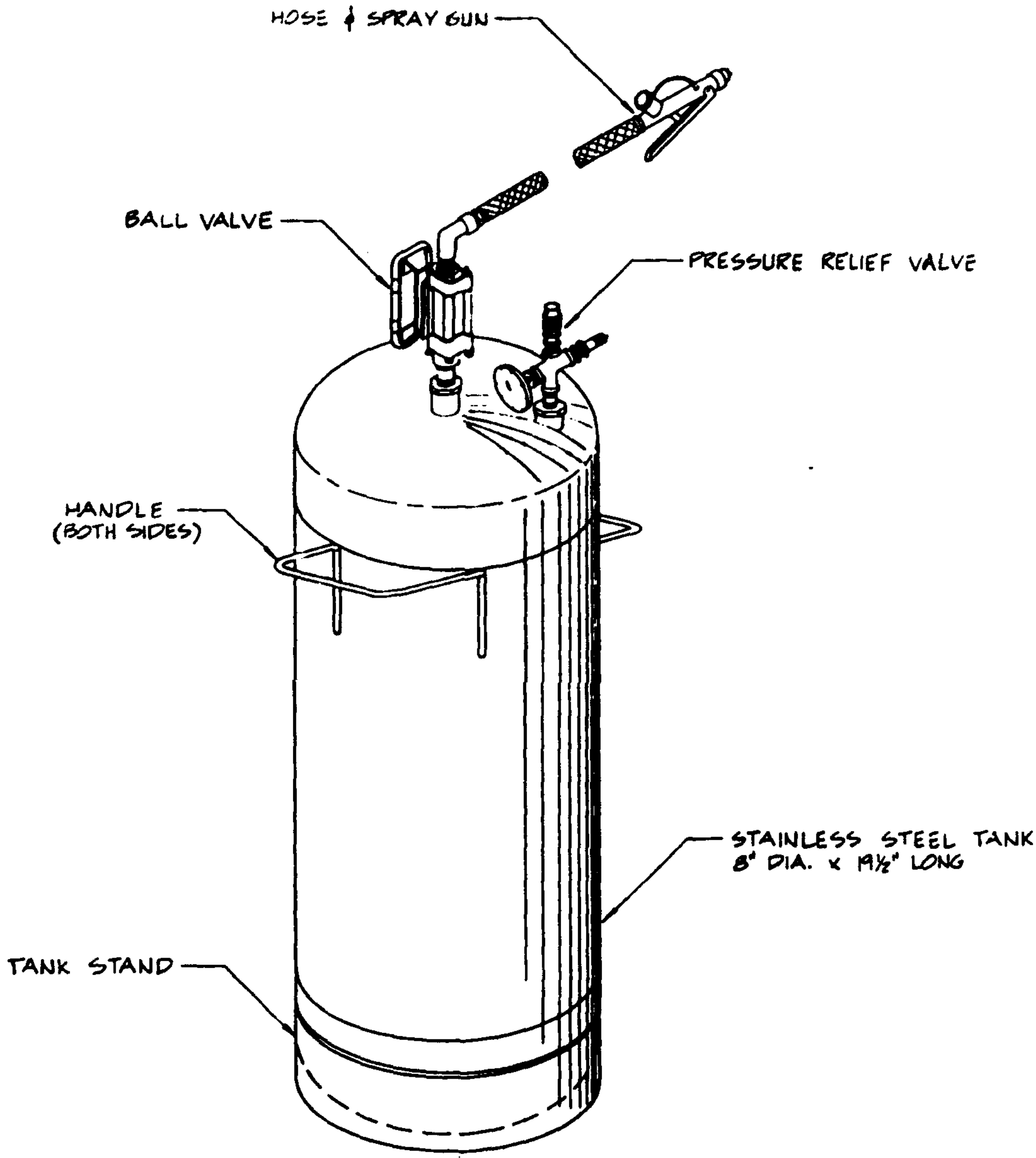


Figure B-1. Prototype Extinguisher.

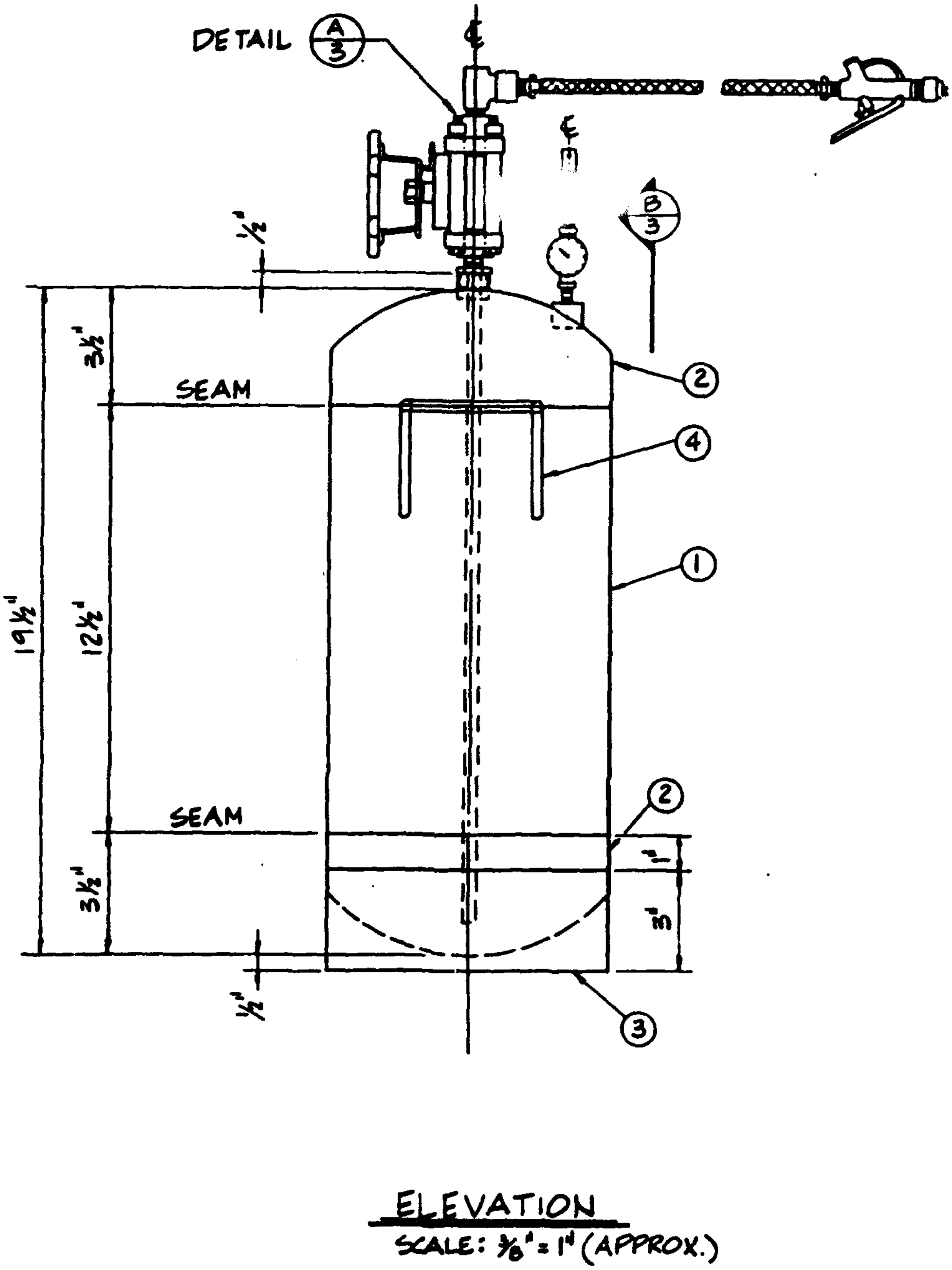


Figure B-2. Prototype Extinguisher - Detail 1, Dimensional Overview.

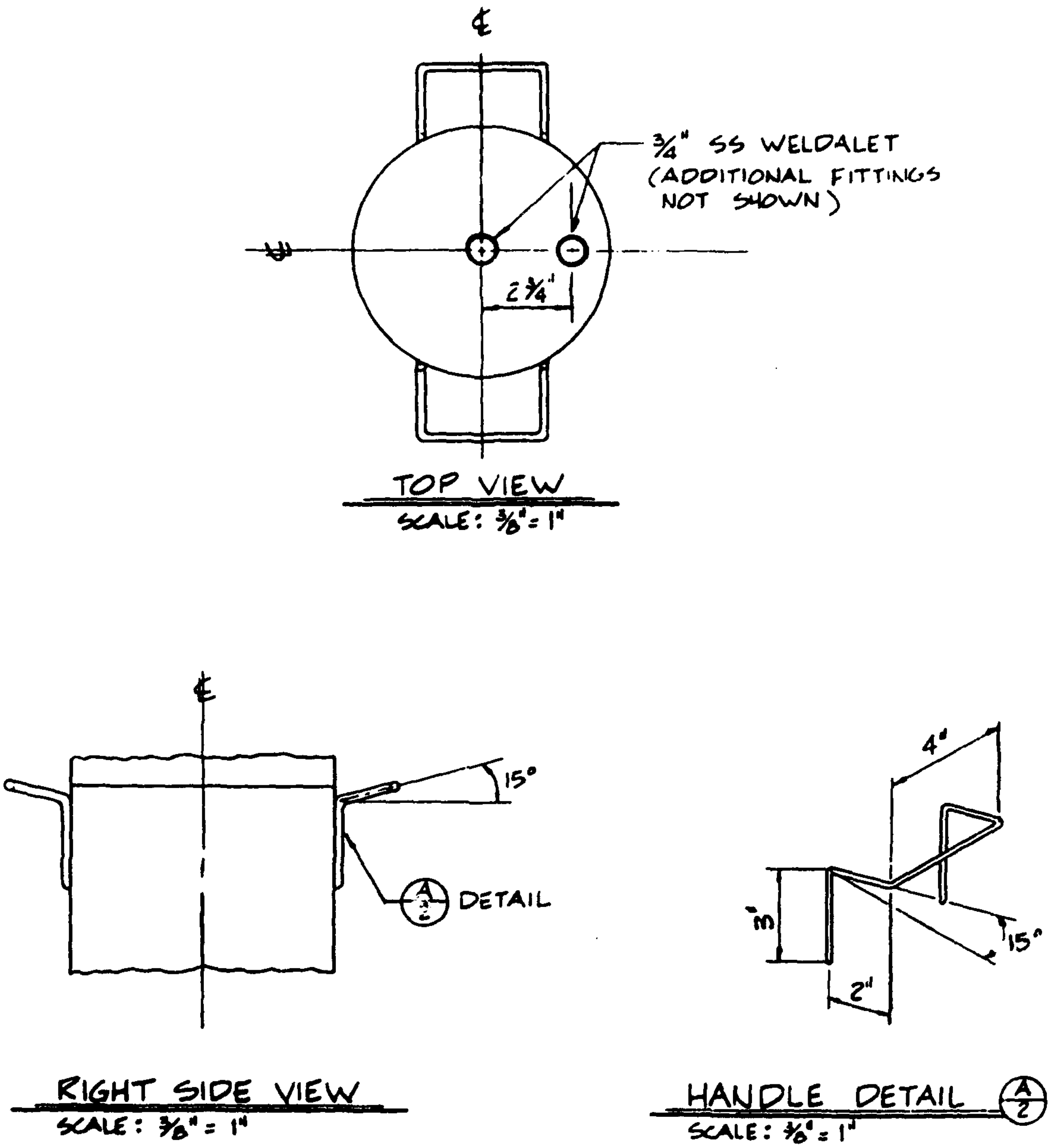


Figure B-3. Prototype Extinguisher - Detail 2, Handle and Top View.

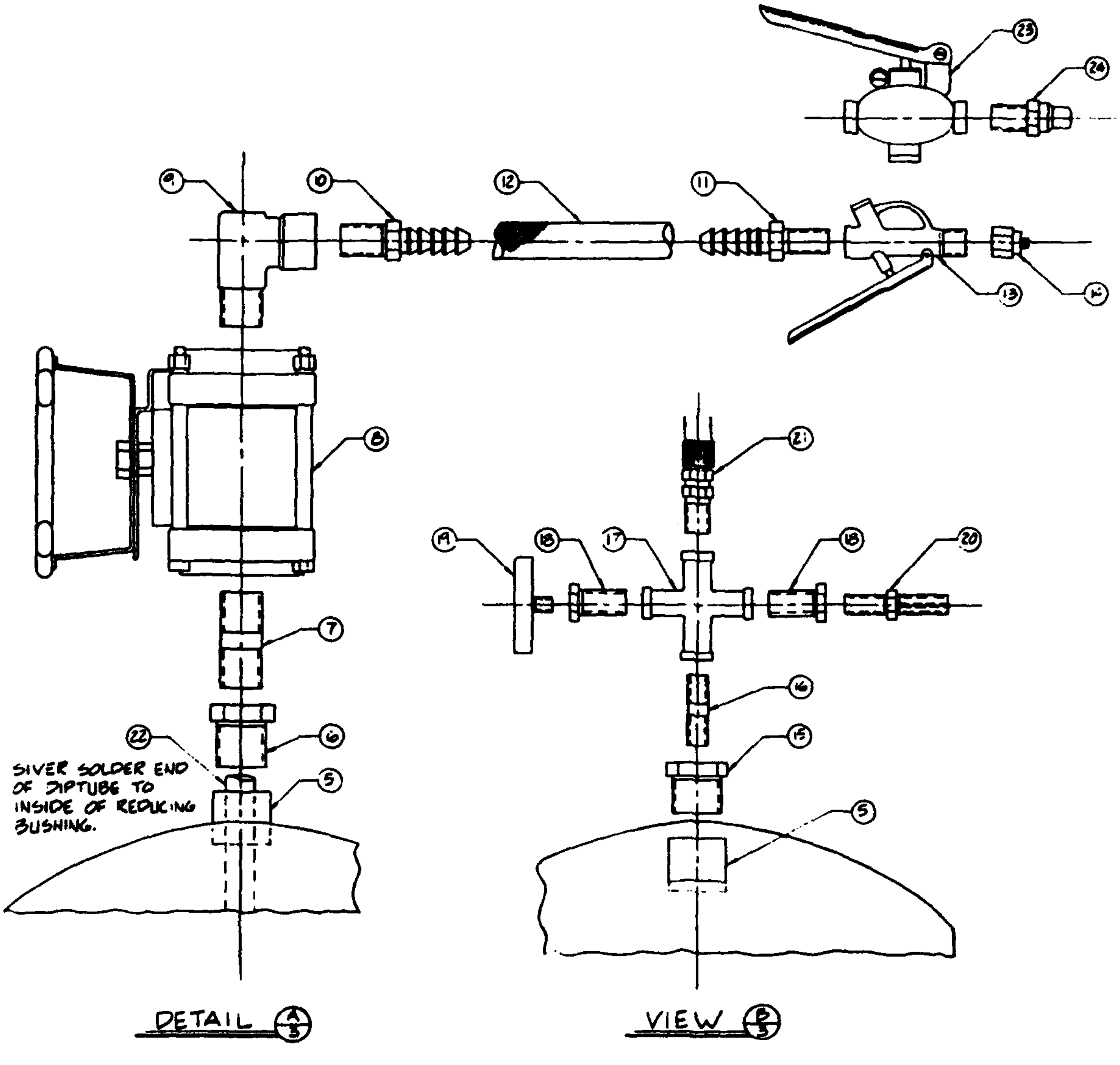


Figure B-4. Prototype Extinguisher - Detail 3, External Fittings.

24	1	NOZZLE. "VEEJET" TYPE H-U SOLID STREAM — OPTION
23	1	SPRAY GUN, "SPRAYING SYSTEMS" MOD. 36 — OPTION
22	1	DIPTUBE, ½" THINWALL TUBING x 19" LG., SS
21	1	PRESSURE RELIEF VALVE, "NUPRO" SS-4CPA2-150 (SET @ 250 P.S.I.)
20	1	STEM VALVE, "NAPA" 90-294
19	1	PRESSURE GAUGE, 1½" FACE, ⅛" MPT REAR MOUNT FITTING, 300 P.S.I. RANGE
18	2	¼" TO ⅛" REDUCING BUSHING, SS
17	1	CROSS FITTING, ¼" FPT, SS
16	1	¼" CLOSE NIPPLE, SS
15	1	¾" TO ¼" REDUCING BUSHING, SS
14	1	NOZZLE, "UNIJET" TYPE ¼ TT
13	1	SPRAY GUN, "SPRAYING SYSTEMS" MOD. 6466
12	1	⅝" O.D. HOSE "IMPERIAL EASTMAN HYTRON" HP006 250 P.S.I. W.P. x 38" LG.
11	1	¼" MALE HOSE CONNECTOR
10	1	½" MALE HOSE CONNECTOR
9	1	½" STREET ELBOW
8	1	BALL VALVE "WHITEY" B-63TF8(K)(L)
7	1	½" CLOSE NIPPLE, SS
6	1	¾" TO ½" REDUCING BUSHING, SS
5	2	¾" WELDALET, SS
4	2	¼" Ø ROD HANDLE x 16" LG. (APPROX.), SS
3	1	SCHED. 10, 8" PIPE-STAND x 3" LG., SS
2	2	SCHED. 10, CAPS, 8.625 O.D., 8.329 I.D., .148 WALL THK. x 3½" LG., SS
1	1	SCHED. 10, 8" PIPE, 8.625 O.D., 8.329 I.D., .148 WALL THK., x 12½" LG., SS
ITEM	REQ'D	DESCRIPTION

Figure B-5. Parts List Prototype Extinguisher.

APPENDIX C
TEST DATA

MEDIUM-SCALE FIELD TEST DATA

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale Test 1

DATE 12/11/87

TIME OF DAY 1100

WIND 5 MPH S-SW

WEATHER Sunny and Clear

FUEL(S) 1480 3.26 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 65.15 pounds

EXTINGUISHER FINAL WEIGHT(S) 54.5 pounds 10.65 pounds of agent was used

APPLICATION TIME 15 to 20 seconds

FLOW RATE 31.8 to 42.6 pounds/second (2.4 - 3.65 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS Magnesium block fell off stand after ignition.

Extinguished fire from 10 feet.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale Test 2

DATE 12/11/87

TIME OF DAY 1130

WIND 5-8 MPH S-SW

WEATHER Sunny and Clear

FUEL(S) 3.14 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 54.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 48.75 pounds 5.75 pounds of agent was used.

APPLICATION TIME 20 seconds in 2-3 second bursts.

FLOW RATE 24.6 pounds/minute (2.11 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS No agent was added to amount used in test number 1.

Unit was repressurized to 200 psi.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale Test 3

DATE 12/11/87

TIME OF DAY 1215

WIND 5-10 MPH S-SW

WEATHER Sunny

FUEL(S) 3.15 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 1560

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 64.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 52 pounds 12.5 pounds of agent was used.

APPLICATION TIME 12 to 20 seconds

FLOW RATE 37.5 pounds/minute (3.22 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS Extinguishing range was increased to 15 - 20 feet.
Fire was approached from upwind side.
A small amount of agent was applied to completely extinguish the fire after the initial application of 12 to 20 seconds.

CONCLUSIONS Spray pattern of nozzle was too disperse to be effective.

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale 4

DATE 12/11/87

TIME OF DAY 1234

WIND 5-8 MPH S-SW

WEATHER Sunny

FUEL(S) 3.34 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 1560

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 52 pounds

EXTINGUISHER FINAL WEIGHT(S) 33.5 pounds 18.5 pounds of agent was used.

APPLICATION TIME 20 seconds in 1 to 2 second bursts with 1 to 2 second intervals.

FLOW RATE 27.0 pounds/minute (2.32 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS Extinguishing range of 15 to 20 feet.

Fire approached from upwind side.

No agent was added to amount used in test number 3. Unit was repressurized to 200 psi.

Fire not completely extinguished.

All useable agent was used on fire.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale Test 5

DATE 12/11/87

TIME OF DAY 1320

WIND 5-10 MPH S-SW

WEATHER Sunny

FUEL(S) 3.65 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 66.4 pounds

EXTINGUISHER FINAL WEIGHT(S) 61.0 pounds 5.4 pounds of agent was used.

APPLICATION TIME 10 to 12 seconds in 1 to 2 second bursts with 2 to 3 second intervals.

FLOW RATE 54.0 pounds/minute (4.63 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS Initial extinguishing range was 12 feet from fire. Fire fully involved. Straight-stream nozzle did very well, put fire out in bursts of 1 - 2 seconds each, 4 - 5 bursts. Agent amount was 2.5 gallons.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale Test 6

DATE 12/11/87

TIME OF DAY 1345

WIND 5-10 MPH S-SW

WEATHER Sunny

FUEL(S) 3.2 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 61.0 pounds

EXTINGUISHER FINAL WEIGHT(S) 41.75 pounds 19.25 pounds of agent was used.

APPLICATION TIME 28 seconds in 3 to 4 second bursts.

FLOW RATE 41.4 pounds/minute (3.55 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS Initial fire was extinguished rapidly.

Inaccessible fires required more agent application.

No agent was added to amount used in test number 5.

Unit was repressurized to 200 psi.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Medium-Scale Test 7

DATE 12/11/87

TIME OF DAY 1410

WIND 5-10 MPH S-SW

WEATHER Sunny

FUEL(S) 3.04 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0020 with flow straightener

EXTINGUISHER TYPE(S) MSA Prototype

EXTINGUISHER PRESSURE 100 psi

EXTINGUISHER INITIAL WEIGHT(S) 40 pounds

EXTINGUISHER FINAL WEIGHT(S) 29 pounds 11 pounds of agent was used.

APPLICATION TIME 35 secconds in large bursts

FLOW RATE 18.6 pounds/minute (1.6 gallons/Minute)

TEST PERSONNEL J. Watson, B. Dees, M. Lee

COMMENTS Flow straightener works well but Halon 1211 seemed not be mixed with TMB well. "Popping" of fire occured when agent was applied. This "popping" cound have been caused by the reaction of the fine (hard-hitting) stream breaking the Mag apart.

CONCLUSIONS

LARGE-SCALE FIELD TEST DATA

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 1

DATE 12/15/87

TIME OF DAY 1330

WIND 12 MPH

WEATHER Overcast

FUEL(S) 30 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 66.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 39.5 pounds 27 pounds of agent was used

APPLICATION TIME 3 minutes 18 seconds

FLOW RATE 8.1 pounds/minute (0.71 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS .0020 nozzle too small for quick knock down of fire.

Dip tube too short-not expelling all the Boralon.

Ignition time 11 minutes 38 seconds.

Application was not continuous.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 2

DATE 12/15/87

TIME OF DAY 1600

WIND 5 MPH

WEATHER Overcast

FUEL(S) 15 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0030

EXTINGUISHER TYPE(S) MSA Prototype

EXTINGUISHER PRESSURE 100 psi

EXTINGUISHER INITIAL WEIGHT(S) 38.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 18.5 pounds 20 pounds of agent was used

APPLICATION TIME 2 minutes 5 seconds

FLOW RATE 9.61 pounds/minute (0.85 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Effective against small magnesium fire.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 3

DATE 12/16/87

TIME OF DAY 1330

WIND 8-10 mph

WEATHER partly cloudy

FUEL(S) 15 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1719 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 63.75 pounds

EXTINGUISHER FINAL WEIGHT(S) 34 pounds 29.75 pounds of agent was used

APPLICATION TIME 1 minute

FLOW RATE 29.75 pounds/minute (2.62 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees.

COMMENTS Weight of extinguisher, nozzle, and TMB - 52.25 pounds

Dip tube was replaced.

Flowrate is approximated.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 4

DATE 12/16/87

TIME OF DAY 1430

WIND 8-10 mph

WEATHER partly cloudy

FUEL(S) 15 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) Standard Halon 1211 extinguisher type

EXTINGUISHER TYPE(S) Standard Ansul 2 1/2 gallon Halon 1211 extinguisher (12 pounds empty w/base)

EXTINGUISHER PRESSURE 150 psi

EXTINGUISHER INITIAL WEIGHT(S) 43.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 22.5 pounds 21 pounds of agent was used

APPLICATION TIME 2 minutes 11 seconds

FLOW RATE 9.62 pounds/minute (0.85 gallons/minute)

TEST PERSONNEL J. Watson, B. Dees.

COMMENTS Total weight of extinguisher, nozzle and TMB = 32 pounds.

Flowrate is approximated.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 5

DATE 12/16/87

TIME OF DAY 1600

WIND 8-17 mph

WEATHER Partly Cloudy

FUEL(S) 15 pounds Magnesium

AGENT(S) Boralon Mixture

NOZZLE(S) .1719 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 150 psi

EXTINGUISHER INITIAL WEIGHT(S) 67.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 34 pounds 33.5 pounds of agent was used.

APPLICATION TIME 1 minute

FLOW RATE 33.51 pounds/minute (2.94 gallons/minute)

TEST PERSONNEL B. Dees, B. Watson, Arnold

COMMENTS Agent mixture of 10 quarts TMB, 10 pounds Halon 1211. Dropped operating pressure to 150 psi.

Total weight of extinghisher, hose and TMB = 57.5 pounds.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 6

DATE 12/19/87

TIME OF DAY 1000

WIND 10 mph from East

WEATHER partly cloudy

FUEL(S) 20 pounds Magnesium

AGENT(S) Boralon Mixture

NOZZLE(S) 0.1719 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 71.75 pounds

EXTINGUISHER FINAL WEIGHT(S) 33.75 pounds 38 pounds of agent was used

APPLICATION TIME 1 minutes 30 seconds

FLOW RATE 25.32 pounds/minute (2.23 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Agent mixture of 10 quarts TMB, 13 pounds Halon 1211

Malfunctioning pressure gauge - pressure equalized at 200 psi with pressure/charging regulator.

Total weight of extinguisher, hose, TMB = 58.75 pounds.

Some burning Magnesium left underneath extinguished mag pile.

Flowrate is approximated.

CONCLUSIONS This amount of agent extinguishes a 20 pound Magnesium fire.

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 7

DATE 12/19/87

TIME OF DAY 1115

WIND 8-12 mph Easterly

WEATHER Overcast

FUEL(S) 25 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1719 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 64.75 pounds

EXTINGUISHER FINAL WEIGHT(S) 34.25 pounds 30.5 pounds of agent was used

APPLICATION TIME 2 minutes 17 seconds (intermittent)

FLOW RATE 13.36 pounds/minute (1.176 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Total weight of extinguisher, hose, TMB = 54.25 pounds.

Pressure gauge was replaced.

Flowrate is approximated.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 8

DATE 12/19/87

TIME OF DAY 1210

WIND 8-12 mph Easterly

WEATHER Partly cloudy

FUEL(S) 40 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1563 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 67.25 pounds

EXTINGUISHER FINAL WEIGHT(S) 35 pounds 32.25 pounds of agent was used

APPLICATION TIME 1 minute 2 seconds

FLOW RATE 31.21 pounds/minute (2.75 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Total weight of extinghisher, hose and TMB = 54.75 pounds.
Began approach to fire at a distance of 18 feet then moved in to
8 feet then final extinguishment accomplished at 6 feet or less.

CONCLUSIONS 0.1563 inch nozzle works well

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 9

DATE 12/19/87

TIME OF DAY 1314

WIND 8-12 mph

WEATHER Overcast

FUEL(S) 50 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1563 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 69 pounds

EXTINGUISHER FINAL WEIGHT(S) 34.5 pounds 34.5 pounds of agent was used.

APPLICATION TIME 1 minute 46 seconds

FLOW RATE 19.53 pounds/minute (1.72 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Total weight of extinguisher, hose and TMB = 55.25 pounds.

Initial approach to fire at 8 feet then proceeded to within 4 feet

CONCLUSIONS Firefighter had to approach too closely to fire for complete extinguishment.

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 10

DATE 12/19/87

TIME OF DAY 1410

WIND 8-12 mph

WEATHER Overcast

FUEL(S) 80 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1563 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 69 pounds

EXTINGUISHER FINAL WEIGHT(S) 33.75 pounds 35.25 pounds of agent was used

APPLICATION TIME 1 minute 29 seconds

FLOW RATE 23.76 pounds/minute (2.09 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Total weight of extinguisher, hose and TMB = 55.25 pounds. Initial approach to fire at 8 to 10 feet then proceeded to within 6 feet.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 11

DATE 12/19/87

TIME OF DAY 1515

WIND 8-15 mph

WEATHER Overcast

FUEL(S) 50 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0030

EXTINGUISHER TYPE(S) MSA

EXTINGUISHER PRESSURE 105 psi

EXTINGUISHER INITIAL WEIGHT(S) 41.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 16 pounds 25.5 pounds of agent was used

APPLICATION TIME 1 minute 50 seconds

FLOW RATE 13.91 pounds/minute (1.22 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Fire not completely extinguished.

MSA unit contained 2 gallons of agent.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 12

DATE 12/21/87

TIME OF DAY 1316

WIND 6 mph SE

WEATHER Overcast - Fog

FUEL(S) 60 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1719 inch

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 68.5 pounds

EXTINGUISHER FINAL WEIGHT(S) 34.75 pounds 33.75 pounds of agent was used.

APPLICATION TIME 1 minute 36 seconds

FLOW RATE 21.09 pounds/minute (1.86 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Total weight of extinguisher, hose and TMB = 55.25 pounds

Defective rubber seal in valve assembly caused spray to widen.

TMB caused deterioration of rubber seal.

Initial approach to fire at 6 feet.

CONCLUSIONS Control was achieved but not total extinguishment.

FIELD TEST DATA SHEET

TEST TYPE Large-Scale Test 13

DATE 12/21/87

TIME OF DAY 1425

WIND 6 mph

WEATHER Overcast

FUEL(S) 55 pounds Magnesium

AGENT(S) Boralon -1-30V

NOZZLE(S) 0.1719 inch with flow straightener & MSA-supplied spray gun

EXTINGUISHER TYPE(S) NMERI Prototype

EXTINGUISHER PRESSURE 200 psi

EXTINGUISHER INITIAL WEIGHT(S) 69.75 pounds

EXTINGUISHER FINAL WEIGHT(S) 34.5 pounds 35.25 pounds of agent was used.

APPLICATION TIME 2 minutes 40 seconds

FLOW RATE 13.23 pounds/minute (1.16 gallons/minute)

TEST PERSONNEL B. Dees, J. Watson

COMMENTS Total weight of extinguisher, hose and TMB = 55.25 pounds.

CONCLUSIONS Control achieved but not total extinguishment.

SPRAY PATTERN FIELD TEST DATA

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 1

DATE 11/23/87

TIME OF DAY 1000

WIND 5 MPH SE

WEATHER Sunny - Partly Cloudy

TEMPERATURE 45°F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 1530

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) NOT RECORDED

EXTINGUISHER FINAL WEIGHT(S) NOT RECORDED

APPLICATION TIME 46 SECONDS

FLOW RATE 3.26 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS NOZZLE WAS PLACED IN A STATIONARY POSITION 3 FEET OFF THE GROUND. NOZZLE ANGLED UPWARD AT A 10° ANGLE.

EFFECTIVE RANGE ~ 22.5 TO 27.5 FEET.

CONCLUSIONS NOT ENOUGH OPERATING PRESSURE

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 2

DATE 11/23/87

TIME OF DAY 1056

WIND 1 MPH

WEATHER HAZY - SUNNY

TEMPERATURE 53°F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 1530

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 150 PSI

EXTINGUISHER INITIAL WEIGHT(S) NOT RECORDED

EXTINGUISHER FINAL WEIGHT(S) NOT RECORDED

APPLICATION TIME 48 SECONDS

FLOW RATE 3.125 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT USED AS BEFORE.

EFFECTIVE RANGE = 20 TO 30 FEET.

CONCLUSIONS OPERATING PRESSURE IS BORDERLINE AND SHOULD BE INCREASED.

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 3

DATE 11/23/87

TIME OF DAY 1127

WIND 2 MPH

WEATHER BREEZZY, COOLER, SUNNY

TEMPERATURE 55° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 1530

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 200 PSI

EXTINGUISHER INITIAL WEIGHT(S) NOT RECORDED

EXTINGUISHER FINAL WEIGHT(S) NOT RECORDED

APPLICATION TIME 45 SECONDS

FLOW RATE 3.33 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.
EFFECTIVE RANGE - 20 TO 27.5 FEET.

CONCLUSIONS INCREASING THE OPERATING PRESSURE INCREASES THE APPLICATION TIME, FLOWRATE AND EFFECTIVE RANGE.

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 4

DATE 11/23/87

TIME OF DAY 1227

WIND 1 MPH

WEATHER CLOUDY - SUNNY

TEMPERATURE 60° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 3 GALLONS

NOZZLE(S) 1530

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 200 PSI

EXTINGUISHER INITIAL WEIGHT(S) NOT RECORDED

EXTINGUISHER FINAL WEIGHT(S) NOT RECORDED

APPLICATION TIME 61.8 SECONDS

FLOW RATE 2.91 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

EFFECTIVE RANGE = 20 TO 25 FEET.

CONCLUSIONS INCREASING AGENT AMOUNT INCREASES APPLICATION TIME, DECREASES FLOWRATE AND EFFECTIVE RANGE.

FIELD TEST DATA SHEET

TEST TYPE Sp. . Pattern Test 5

DATE 11/24/87

TIME OF DAY 1040

WIND 18 MPH NE

WEATHER SUNNY - WINDY

TEMPERATURE 45° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE .5 . LLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 150 PSI

EXTINGUISHER INITIAL WEIGHT(S) 57.4 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 38 POUNDS 19.4 POUNDS AGENT WAS USED.

APPLICATION TIME 61.2 SECONDS

FLOW RATE 2.45 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. RODRIGUEZ, M. LEE, B. TAPSCOTT

COMMENTS SAME NOZZLE PLACEMENT AS IN TESTS 1-4.

WIND SCREENS WERE USED TO SHIELD TEST RANGING BED.

EFFECTIVE RANGE = 25 FEET.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 6

DATE 11/214/87

TIME OF DAY 1110

WIND 10 MPH NW/BARRIER

WEATHER SUNNY - BREEZY

TEMPERATURE 46° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) 57.6 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 37.6 POUNDS 18.9 POUNDS AGENT WAS USED.

APPLICATION TIME 72 SECONDS

FLOW RATE 2.08 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

EFFECTIVE RANGE - 25 FEET.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 7

DATE 11/24/87

TIME OF DAY 1145

WIND 10 MPH NE

WEATHER SUNNY - BREEZY

TEMPERATURE 48^{o} F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 200 PSI

EXTINGUISHER INITIAL WEIGHT(S) 56.8 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 37.6 POUNDS 19.2 POUNDS AGENT WAS USED.

APPLICATION TIME 56 SECONDS

FLOW RATE 2.67 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE - 27.5 FEET.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 8

DATE 11/24/87

TIME OF DAY 1204

WIND 10 MPH NE

WEATHER SUNNY - BREEZY

TEMPERATURE 50° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 1560

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) 58.25 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 37.9 POUNDS 20.3 POUNDS AGENT WAS USED.

APPLICATION TIME 49.6 SECONDS

FLOW RATE 3.02 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. RODRIGUEZ, M. LEE

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND BARRIERS IN USE.

EFFECTIVE RANGE = 22.5 TO 25 FEET

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 9

DATE 11/24/87

TIME OF DAY 1230

WIND 10 MPH NE

WEATHER SUNNY - BREEZY

TEMPERATURE 50° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 1560

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 150 PSI

EXTINGUISHER INITIAL WEIGHT(S) 57.8 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 37.9 POUNDS 20.1 POUNDS AGENT WAS USED.

APPLICATION TIME 38 SECONDS

FLOW RATE 3.95 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND BARRIERS IN USE.

EFFECTIVE RANGE - 25 FEET

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 10

DATE 11/24/87

TIME OF DAY 1249

WIND 10 MPH NE

WEATHER SUNNY - WINDY

TEMPERATURE 54° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 1560

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 200 PSI

EXTINGUISHER INITIAL WEIGHT(S) 57.8 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 32.6 POUNDS 25.24 POUNDS AGENT WAS USED.

APPLICATION TIME 31.6 SECONDS

FLOW RATE 4.75 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE = 27.5 FEET.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 11

DATE 11/24/87

TIME OF DAY 1314

WIND 10 MPH NE

WEATHER SUNNY/WINDY

TEMPERATURE 54° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2 GALLONS

NOZZLE(S) 0030

EXTINGUISHER TYPE(S) MSA PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) NOT RECORDED

EXTINGUISHER FINAL WEIGHT(S) NOT RECORDED

APPLICATION TIME 102 SECONDS

FLOW RATE 1.18 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE = 30 FEET.

FLOW STRAIGHTENER WAS USED WITH NOZZLE ASSEMBLY.

EXTINGUISHER DELIVERED A FINELY CONCENTRATED STREAM OF AGENT.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 12

DATE 11/24/87

TIME OF DAY 1330

WIND 10 MPH NE

WEATHER SUNNY/WINDY

TEMPERATURE 54° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2 GALLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) MSA PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) 36.1 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 15.9 POUNDS 20.2 POUNDS AGENT WAS USED.

APPLICATION TIME 69 SECONDS

FLOW RATE 1.74 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE - 32.5 TO 45 FEET.

FLOW STRAIGHTENER WAS USED WITH NOZZLE ASSEMBLY.

CONCLUSIONS FLOW STRAIGHTENER CONCENTRATES THE FLOW INTO A FINER STREAM AND INCREASES THE THROW RANGE.

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 13

DATE 11/24/87

TIME OF DAY 1345

WIND 10 MPH NE

WEATHER SUNNY/WINDY

TEMPERATURE 54° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2 GALLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) MSA PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) 35.6 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 15.4 POUNDS 20.1 POUNDS AGENT WAS USED.

APPLICATION TIME 70 SECONDS

FLOW RATE 1.71 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE - 30 FEET.

FLOW STRAIGHTENER REMOVED AND NOT USED.

CONCLUSIONS REMOVAL OF FLOW STRAIGHTENER DECREASED THE THROW RANGE.

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 14

DATE 11/24/87

TIME OF DAY 1409

WIND 5 MPH NE

WEATHER WINDY/SUNNY

TEMPERATURE 58° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2.5 GALLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) MSA PROTOTYPE

EXTINGUISHER PRESSURE 100 PSI

EXTINGUISHER INITIAL WEIGHT(S) 35.6 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 16.7 POUNDS 18.9 POUNDS AGENT WAS USED.

APPLICATION TIME 94.2 SECONDS

FLOW RATE 1.59 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE = 20 TO 25 FEET.

FLOW STRAIGHTENER NOT IN USE.

CONCLUSIONS

FIELD TEST DATA SHEET

TEST TYPE Spray Pattern Test 15

DATE 11/24/87

TIME OF DAY 1415

WIND 5 MPH NE

WEATHER WINDY/SUNNY

TEMPERATURE 58° F

FUEL(S) NONE

AGENT(S) METHYL CELLULOSE 2 GALLONS

NOZZLE(S) 0020

EXTINGUISHER TYPE(S) NMERI PROTOTYPE

EXTINGUISHER PRESSURE 200 PSI

EXTINGUISHER INITIAL WEIGHT(S) 54.3 POUNDS

EXTINGUISHER FINAL WEIGHT(S) 38.6 POUNDS 15.7 POUNDS AGENT WAS USED.

APPLICATION TIME 38 SECONDS

FLOW RATE 3.16 GALLONS/MINUTE

TEST PERSONNEL J. WATSON, M. LEE, M. RODRIGUEZ

COMMENTS SAME NOZZLE PLACEMENT AS BEFORE.

WIND SCREENS IN USE.

EFFECTIVE RANGE = 32.5 TO 45 FEET.

DECREASED AGENT AMOUNT TO 2 GALLONS.

FLOW STRAIGHTENER WAS USED WITH NOZZLE ASSEMBLY.

CONCLUSIONS DECREASING THE AGENT AMOUNT INCREASES THE THROW RANGE. FLOW STRAIGHTENER WILL ALSO IMPROVE THROW RANGE.